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The Life History and Some Aspects of the Ecology of the Large Aspen Tortrix, *Choristoneura conflictana* (Wlkr.) (N. Comb.) (Lepidoptera: Tortricidae)[1]

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INTRODUCTION

Periodic outbreaks of the large aspen tortrix, *Choristoneura conflictana* (Wlkr.) severely defoliate trembling aspen, *Populus tremuloides* Michx., in parts of Manitoba and Saskatchewan. The inadequacy of information on the insect prompted further investigation of its life history and the factors affecting its abundance. Field studies were conducted in Northern Manitoba and Saskatchewan, where from 1950 to 1954 the insect was found at various population levels.

SYSTEMATIC POSITION

The large aspen tortrix was originally described by Walker (1863). Walsingham (1879) placed *Tortrix conflictana* in the genus *Heterognomon.* Meyrick (1913) moved it to the genus *Cacoecia,* where it remained until Forbes (1923) placed it in the genus *Archips.* On the basis of information received from Freeman, who plans a general revision of the subfamily Archipinae, *Archips conflictana* (Wlkr.) is here transferred to the genus *Choristoneura,* which was established by Lederer (1859).[3]

HISTORY OF OUTBREAKS

The early records of *C. conflictana* provide only limited information. Outbreaks have been reported by Caesar (1912) in the Toronto area of Ontario in 1912; Hewitt (1920) and Criddle (1918) in southwestern Manitoba in 1916 and 1917; Whitehouse (1920) in Alberta in 1919; and Twinn (1935) in northwestern New Brunswick in 1933 and 1934.

The following review of more recent outbreaks has been compiled from the Annual Reports of the Canadian Forest Insect Survey.

From 1943 to 1946, *C. conflictana* caused severe defoliation of aspen in the Waterton Lakes, Jasper, and Banff national parks in Alberta. During the same period local infestations occurred in the Sault Ste. Marie and Nicholson areas of Ontario. From 1946 to 1948 high populations were present in the Duck Mountain Forest Reserve, Manitoba. In parts of the Reserve, poplar was completely stripped for three consecutive years. The most extensive outbreak of *C. conflictana* reported to date was first detected in The Pas area of northern Manitoba in 1948, and by 1950 it covered approximately 10,000 square miles. In 1951 there was a general decline of populations through the whole of this area and by 1952 the outbreak had completely subsided. In 1950 and 1951 the insect caused heavy defoliation of aspen in parts of northwestern New Brunswick. From 1949 to 1953 small local infestations of *C. conflictana* occurred in northern Saskatchewan. During 1952 and 1953 the insect was found in association with the forest tent caterpillar, *Malacosoma disstria* Hbn., in the Saskatchewan area.

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The two species were also found at high population levels in the Fort Nelson area of British Columbia in 1953.

DISTRIBUTION AND HOSTS

Information on distribution of *C. conflictana* in North America was obtained from collections made by the Canadian Forest Insect Survey and reports from the United States National Museum. The insect occurs in Canada from Newfoundland to British Columbia, as far north as its preferred host, *Populus tremuloides* Michx., extends. The southern limits of the insect in the United States coincide with the occurrence of aspen in Utah, Illinois and New York. Where outbreaks have occurred in Manitoba and Saskatchewan aspen has been present either in pure stands or in mixed stands with aspen the major component. The larvae also feed on balsam poplar, *Populus balsamifera* L., white birch, *Betula papyrifera* Marsh., willows, *Salix* spp., eastern chokecherry, *Prunus virginiana* L., and speckled alder, *Alnus rugosa* (Du Roi), when they occur in outbreak areas.

DESCRIPTION OF STAGES

Egg (Fig. 11)

The eggs of *C. conflictana* are laid in flat clusters ranging from 15 to 85 square mm. in area. Individual eggs are scale-like, oval in outline, and pale-green in colour. They average 1.08 mm. in length and 0.76 mm. in width. The chorion is smooth, thin, and transparent. The number of eggs per cluster ranges from 60 to 450.

Larva (Figs. 1-7)

Head-capsule measurements of insectary-reared and field-collected larvae indicate that there are five instars. Complete series of measurements of insectary-reared larvae were obtained for only four individuals. The measurements fell into discrete groupings and compared favourably with those from the field-collected larvae as shown in Table I.

TABLE I

Head-Capsule Measurements of Insectary-Reared and Field-Collected Larvae

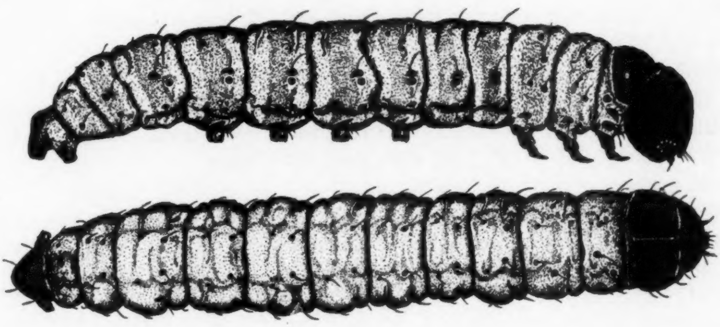
Instar	Insectary-Reared			Field-Collected		
	No.	Mean Width	Range	No.	Mean Width	S.D.
1	10	.286	.253– .312	20	.267	.008
2	5	.390	.371– .410	20	.368	.011
3	4	.629	.605– .663	20	.667	.210
4	4	.994	.975–1.014	20	1.045	.170
5	4	1.570	1.502–1.658	20	1.776	.390

Larval instars may be recognized in the field on the basis of head-capsule width and other descriptive characteristics and habits that will be described.

First Instar

The length ranges from 1.8 to 2 mm. The body colour is pale yellow-green, with head, prothoracic shield, and anal plate light brown. The thoracic legs are

Figs. 1-7. 1, fifth-instar larva; 2, mandible; 3, hypopharynx; 4, setal patterns of prothoracic, mesothoracic and 1st, 6th, 7th, 8th and 9th abdominal segments; 5, crotchets of ventral proleg; 6, crotchets of anal proleg; 7, anal comb.



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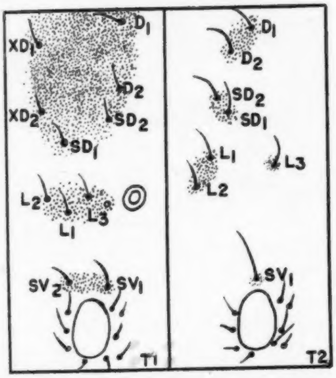
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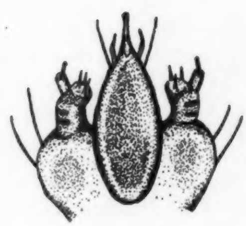

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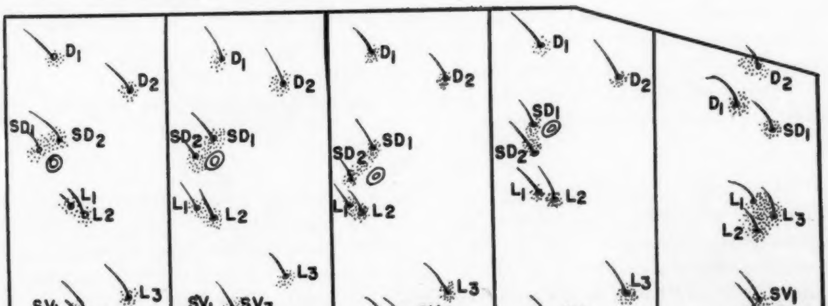
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L3
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L3
L2
SV1
SV2
V1
A9

4

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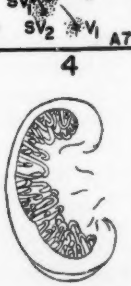

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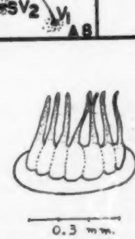
0.3 mm.

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about the same colour as the body sometimes slightly brownish. The setae are long and white with inconspicuous setal bases.

Second Instar

The length ranges from 2.6 to 3.8 mm. The body colour is pale green, with head, prothoracic shield, and anal plate dark brown. Setae are similar to those of first-instar larvae with dark grey setal bases.

Third Instar

The length ranges from 4 to 7 mm. The body colour changes to greyish-green. The head, prothoracic shield and anal plate are dark brown, almost black. The setae are grey with black setal bases.

Fourth Instar

The length ranges from 10 to 14 mm. The body colour is darker, otherwise similar to the previous instar.

Fifth Instar (Figs. 1 to 7)

The fifth-instar larvae (Fig. 1) range in length from 15 to 21 mm. The body colour is dark green, sometimes almost black. The head and anal plate are black, sometimes reddish-brown, but usually uniform in colour. The prothoracic shield is reddish-brown to black, light brown along the anterior margin.

Each mandible (Fig. 2) has five teeth, the first truncate, the remainder pointed. The ventral aspects of the median area of the apical tooth has three, sometimes two internal teeth. The hypopharynx (Fig. 3) has a bulbous lingua, with very minute spines; the gorge of the lingua is inconspicuous. The spinneret is tapered from the base, and about three times as long as its width at the widest point.

The thoracic legs are black, the ventral and anal prolegs are about the same colour as the body and have a dark median band. The crotchets of the ventral prolegs (Fig. 5) are uniserial, triordinally arranged in a circle and number approximately 55. The crotchets of the anal prolegs (Fig. 6) are uniserial, triordinally arranged in a semicircle and number approximately 45. The anal comb (Fig. 7) is conspicuous, usually with seven finger-like prongs.

The setal pattern of the thoracic and abdominal segments as classified by Hinton (1946) is shown in Fig. 4.

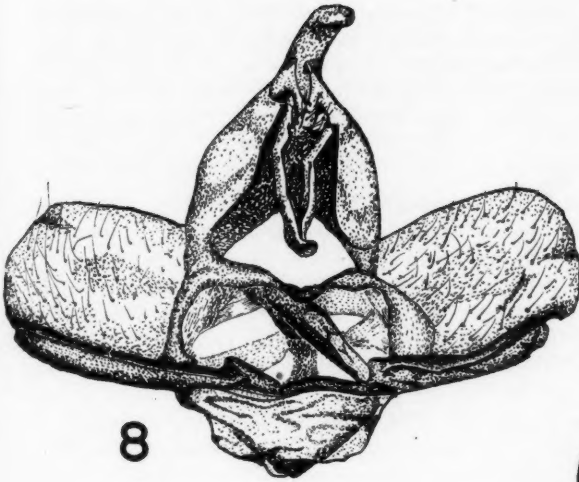
Pupa (Fig. 12)

The length of male pupae ranges from 9 to 14 mm.; the width from 2.5 to 3.5 mm. The length of female pupae ranges from 13 to 17 mm.; the width from 3.5 to 4.5 mm. The pupae are bright green when first formed, later changing to reddish-brown or black. Male pupae have five abdominal segments visible from the ventral side; females have only four. The last larval exuvia is usually attached to the base of the pupa.

Adult (Figs. 8-10 and 13)

The adult of *C. conflictana* is a medium sized moth (Fig. 13). The males have a wing span of 25 to 28 mm.; the females, from 27 to 35 mm. The body length of males ranges from 10 to 12 mm., and of the females from 11 to 15 mm.

The antennae are dark grey, composed of 39 to 50 segments. The head and body are fuscous, lighter at the junction of the abdominal segments. The legs are light grey flecked with dark grey. The forewings are light grey with fuscous maculations consisting of an inner patch, a median band, and an outer patch. The outside margin of the inner patch is distinct and extends from the inner quarter of the costa to the inner third of the hind margin. The median band extends from the mid-portion of costa to the hind margin, and is expanded



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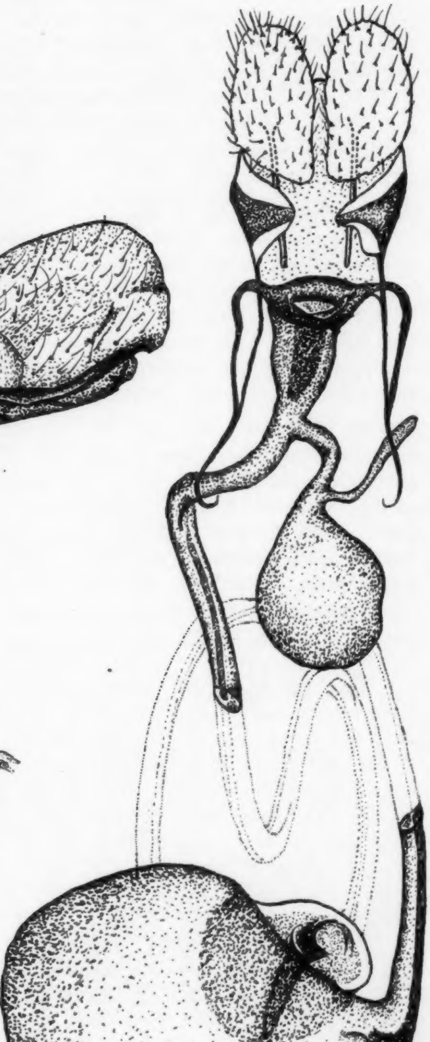

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Figs. 8-10. 8, male genitalia; 9, aedoeagus; 10, female genitalia.

inwardly and outwardly at about its mid-point. The outer margin of the median band almost reaches the anal angle. The outer patch is less distinct, usually formed by short broken striae. The inner margin of the outer patch extends from the outer quarter of the costa to the anal angle. The fringe of the forewing is light grey with a darker basal line. The hind wing is dark-smoky, lighter along the anterior margin. The fringe of the hind wing is light grey with a darker basal line. The undersurface of the hind wings is medium grey, the maculations of the forewing extending ventrally to the costal margin of the underside.

Male Genitalia (Figs. 8 and 9)

The claspers are wide at the base, broadly rounded at the apex. The sacculus is heavily sclerotized, narrow, and extends almost to the apex of the clasper. The aedoeagus is curved ventrally with an apical tooth and deciduous cornuti. The gnathos is long, formed by two arm-like structures, joined and curved at the distal end. The soccii are about three times as long as wide and are hairy. The transtilla is of medium width, folded in the centre to form a lip. The uncus is long, strongly curved, and widened at the tip.

Female Genitalia (Fig. 10)

The ovipositor lobes are flat and oval, about twice as long as broad. The posterior apophyses are long, the anterior apophyses branched at the junction of the ovipositor lobes. The ostium is large, completely encircled by the ostial plate. The distal end of the ductus bursae is enlarged, sclerotized towards the centre. A sclerotized band extends from near the distal end of the ductus bursae to the bursa. The bursa copulatrix is large and rounded with a heavily sclerotized raised signum, curved and extending deep into the bursa.

LIFE HISTORY AND HABITS

The eggs of *C. conflictana* are laid from mid-June to early July. The larvae appear from early July to mid-July and feed on the epidermal layers of leaf tissue until the latter part of August. At this time the larvae congregate at the base of the tree trunk to overwinter in small white hibernacula. The larvae emerge from hibernation in early May of the spring following hatching. They crawl up the tree trunk and later mine the developing poplar buds. After the buds open and the leaf cluster forms the larvae feed more openly. It is during this phase of larval development that most of the defoliation occurs. Pupation takes place within rolled leaves from early June to mid-June and the moths emerge 10 to 14 days later.

The data presented in Table II give the mean dates of occurrence of various stages of *C. conflictana* in Manitoba and Saskatchewan from 1951 to 1954. The data are based on field observations and insectary rearings.

TABLE II

The Mean Dates of Occurrence of Various Stages of *C. conflictana* from 1951–1954

Year	Location	First Report of Larval Activity	Mean Date of Pupation	Mean Date of Adult Emergence	Last Report of Larval Activity
1951	The Pas, Man.	May 12	June 20	June 28	Aug. 15
1952	Glaslyn, Sask.	May 1	June 2	June 18	Aug. 24
1953	Glaslyn, Sask.	May 5	June 2	June 17	Aug. 20
1954	Glaslyn, Sask.	May 15	June 15	June 22	Aug. 15

Egg Stage

The eggs are laid in flat clusters on the upper surface of aspen leaves. Oviposition was not studied extensively in the field, but observations indicate that the moths usually deposit only one cluster of eggs. Oviposition occurs from mid-June to early July. Eggs deposited by caged females required an incubation period of seven days. The incubation period under field conditions is not known, but the peak of moth flight in the Meadow Lake area of Saskatchewan in 1951 was on June 21 and the first hatched eggs were found in this area on July 1 indicating an incubation period of nine to ten days. After the larvae hatch, the white and translucent egg shells remain on the leaves until after leaf fall.

Larval Stage

First-instar larvae may be found from early July to the latter part of August. Upon hatching the larvae are very active and frequently hang on spun threads, indicating that there is a migratory phase. The small larvae are gregarious and appear to prefer a closed habitat. Four or five individuals web the flat surfaces of the leaves together and feed within. During this phase of development the larvae feed on the upper and lower layers of epidermal leaf tissue, giving the leaves a skeletonized appearance. However, feeding damage is not conspicuous at this time.

Movement to hibernation sites commences in early August and is completed by the latter part of August. Larvae overwinter in small white hibernacula, which are usually spun in the bark crevices along the lower portion of the trunk. When rough bark is scarce or absent, the larvae hibernate under the layer of moss that usually grows on the base of the trunk (Fig. 14).

The actual movement of larvae to hibernating sites was not observed during the present investigation. Some evidence was obtained which indicated that the larvae move down the trunk and spin hibernacula in the first suitable niche encountered. It is possible however that they drop by hanging on threads, and further that many spin up in the ground around the trunk.

Before hibernating the larvae undergo their first moult; the cast skin and head capsule are usually attached to the outside of the hibernacula.

The second-instar larvae emerge from hibernation and ascend the trees from early May to mid-May of the following spring, usually about 10 to 12 days before the aspen buds break. After the larvae ascend the trees they frequently hang from spun threads indicating a second migratory phase. Before feeding the larvae are sometimes exposed to unfavourable weather conditions. During such periods they spin what appear to be secondary hibernacula at the base of the aspen buds. This appears to be a facultative response to unfavourable weather.

The small larvae mine the aspen buds shortly after they begin to swell (Fig. 15). In 1953, the first mined buds were found on May 10, in the Lac La Ronge area of Saskatchewan. In 1954, in the same area, bud mining did not occur until May 21. During this investigation, generally only one larva was found per mined bud, though two or three larvae were sometimes present. The number entering individual buds probably depends on the population density. The second larval moult occurs within the bud. When the buds break and the leaf clusters expand, the leaves within which the larvae fed in the buds fail to develop. The petioles elongate but the blades remain curled and eventually die. The larvae remain in these leaves until just prior to the third moult. Some of the remaining leaves in the leaf clusters show holes as a result of bud mining activity (Fig. 16). de Gryse (1924) probably referred to these holes when he stated, "The larvae attack the foliage as soon as the buds burst. At first they eat holes in the leaves

and later curl them by means of webbing." When the leaves are expanded, the larvae move from the destroyed leaves and resume feeding. They roll leaves and feed within the enclosures. At this stage the larvae consume all portions of the leaf substance attacked. During the fourth and fifth instar the larvae continue to feed in this manner. The bulk of defoliation occurs during this stage of larval development. The fourth and fifth instar and intervening moult take a total of 10 to 12 days to complete. In areas of severe defoliation (Fig. 17), the larvae frequently drop to the understory and cause extensive webbing (Fig. 18). Pupation occurs within the rolled leaves in which the larvae have been feeding. The larval exuviae are usually found attached to the pupae.

Pupal Stage

The length of the pupal period varies according to weather conditions. Under insectary conditions the shortest pupal period was seven days and the longest fourteen days, with an average of eight days. In 1953 the first pupae were found in the Lac La Ronge area on June 9, and on June 19, the first moths were observed, indicating a pupal period of about ten days. Pupae are usually found on the aspen foliage, but in areas of severe defoliation pupae are found in the leaves of the understory.

Adult Stage

Information on adult emergence was gathered mainly from insectary rearings. In 1951 adults emerged from June 27 to July 2; the peak of emergence was June 28. In 1952 moths emerged from June 16 to June 24, and the peak of emergence was on June 18. The sex-ratio of insectary reared adults was approximately 1:1. In 1951 large moth flights were reported from the Meadow Lake outbreak area in Saskatchewan on June 27. In 1952 in the same area the peak of the moth flight period was June 21. Mature eggs in the ovaries of 10 virgin females averaged 244, ranging from 198 to 398 per individual. These counts when compared with the number of eggs per cluster found in the field indicate that sometimes more than one cluster is deposited.

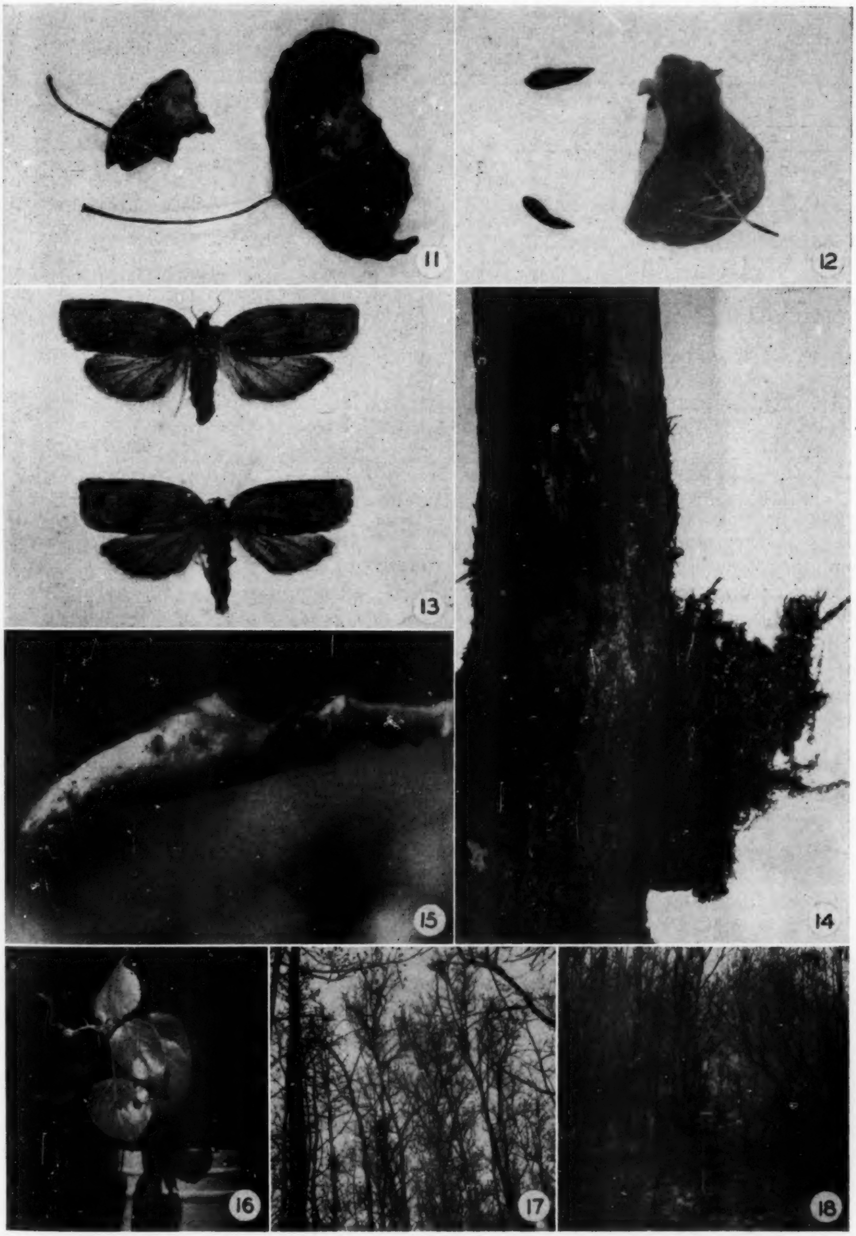
LARVAL SAMPLING

The early spring activities of *C. conflictana* have been previously outlined. Second- and third-instar larvae remain in mined buds and developing leaf clusters for a period of 10 to 14 days and may be conveniently sampled during these stages. Sampling at this time would provide estimates of the potential defoliation population and thus form the basis for defoliation forecasts.

Experimental sampling was conducted in the spring of 1953 in an estimated light to moderate infestation in the Lac La Ronge area of Saskatchewan. Trees, ranging from 3 to 10.5 inches d.b.h. and 31 to 70 feet in height, were felled and divided into three equal crown levels. One branch was selected from each of four cardinal points at each crown level. Twenty-five buds or developing leaf clusters were examined from each branch and recorded as infested or uninfested. Data were collected from twenty-five trees. The proportion of buds and developing leaf clusters infested with larvae ranged from 0.35 to 0.80 per tree.

The data were submitted to an analysis of variance to determine intra- and inter-tree variability in distribution of larvae. The results of the analysis are shown in Table III.

The analysis indicates significant differences between trees and crown levels, and interactions between trees and crown levels. Therefore these would have to be considered when sampling. The analysis indicates no directional differences in the distribution of larvae, so directions may be ignored when sampling.



Figs. 11-18. 11, emerged egg clusters; 12, pupae; 13, adults; 14, hibernacula spun in moss at the base of the trunk; 15, mined bud; 16, leaf cluster showing holes due to mining activity; 17, severely defoliated aspen; 18, defoliation and webbing in the understory. (Photographs by B. McLeod).

TABLE III
Analysis of Variance Showing Variation between Trees, Crown Levels and Directions, and their Interactions

Source of Variation	D.F.	S.S.	M.S.	F.
Between trees..................	24	2115.3	88.14	4.00*
Between crown levels............	2	506	253.05	11.49*
Between directions..............	3	16.3	5.43	.60
Trees x crown levels............	48	1056.9	22.02	2.45*
Trees x directions..............	72	264.0	3.53	.39
Crown levels x directions........	6	30.1	5.02	.56
Error..........................	144	1293.1	8.98	
Total..........................	299	5272.6		

*Significant at the 1% level.

If the same sampling method (100 buds from each of three crown levels eliminating directions), is used, the number of trees that would have to be sampled may be estimated from the experimental sampling data gathered in 1953. The sample sizes are based on the tree total means, making use of the relationship $d < s_{\bar{x}} t\alpha$ which gives $n_0 = \frac{s^2 t^2\alpha}{d^2}$ where d is half the confidence interval width, and $s_{\bar{x}} = \frac{s}{\sqrt{n}}$ is the standard error of the mean, and t is the students t for α confidence level, based on infinite degrees of freedom. The size of samples required for given degrees of accuracy is shown in Table IV.

The sample size estimates shown above are based on experimental sampling for only one season, at one location, and at one population density. Both the analysis and the sample size estimates would not necessarily apply at different levels of infestation. However, the data indicate a practical approach to measuring early spring larval populations. Providing further experimental data can be gathered at different infestation levels it should be possible to develop a sequential system of sampling similar to that developed by Morris (1954) for spruce budworm and Stark (1952) for lodgepole needle miner.

TABLE IV
Estimated Sample Size for Given Degrees of Accuracy

Confidence Level	(d)	Per Cent of Observed Mean	Estimated No. of Trees
95	16	10	16
90	16	10	11
95	24	15	7
90	24	15	4

TABLE V
Parasites Reared from *C. conflictana* in Manitoba and Saskatchewan

HYMENOPTERA	Pteromalidae
Ichneumonoidea	**Catolaccus aeneoviridis* (Gir.)
Ichneumonidae	**Amblymerus* sp.
Glypta fumiferanae (Vier.)	
Phytodietus burgessi (Cress.)	DIPTERA
Phytodietus vulgaris Cress.	Tachinidae
Ischnus sp. n. *atricollaris*	*Phyrxe pecosensis* Tns.
Itoplectis conquisitor (Say)	*Actia interrupta* Cn.
Phaeogenes cacoeciae Vier.	*Actia diffidens* Cn.
Braconidae	*Eumea caesar* (Ald.)
Macrocentrus iridescens French	*Omotoma fumiferanae* Tothill
Agathis annulipes (Cress.)	*Lypha setifacies* (West.)
Apanteles sp.	*Madremyia saundersii* (Will.)
Microgaster canadensis Mues.	Sarcophagidae
Chalcidoidea	*Pseudosarcophaga affinis* (Fall.)
Eulophidae	Phoridae
Sympiesis sp.	*Megaselia* sp. (questionable parasite)

*Hyperparasite.

Henson (1954) developed a system for sampling a number of organisms, including *C. conflictana,* attacking trembling aspen. His sampling unit was the leaf bunch or leaf cluster which is the same unit as the bud. His method however applies to the later larval feeding stages. It is possible that with further studies and modifications the two sampling methods could be applied to follow the trend of a given larval population through its development in any one season.

NATURAL CONTROL FACTORS

This investigation provided information on a number of natural control factors, mainly parasites, predators and disease, affecting the abundance of *C. conflictana.*

Parasites

Collections of larvae and pupae of *C. conflictana* received at the Winnipeg laboratory by the Forest Insect Survey in Manitoba and Saskatchewan from 1951 to 1954 were reared for parasite recovery. The collections were made during all phases of larval and pupal development. The parasites recovered are listed in Table V.

Additional parasites reared from host material collected elsewhere in Canada are listed in Table VI. This information was obtained from other Canadian Forest Insect Survey laboratories.

The most common larval parasites reared from host material collected in Manitoba and Saskatchewan were *Glypta fumiferanae* (Vier), *Apanteles* sp., *Macrocentrus iridescens* French., *Microgaster canadensis* Mues., *Eumea caesar* Ald., *Omotoma fumiferanae* Tothill, and *Actia interrupta* Cn. The most common pupal parasites were *Itoplectis conquisitor* Say and *Pseudosarcophaga affinis* Fall. The remainder of the parasites were recovered only occasionally.

There were no intensive studies conducted to determine the effectiveness of parasites in any one outbreak area. Such studies require detailed information on host-parasite relations, which was not available prior to the present investigation. However, the results of general collections and rearings indicate that *C. conflictana* has an extensive complement of parasites, many of which are also parasites of such common forest insects as the spruce budworm, *Choristoneura fumiferana*

TABLE VI

Parasites Reared from Host Material Collected Outside of Manitoba and Saskatchewan

Parasite	Location
Hymenoptera	
Ichneumonoidea	
Ichneumonidae	
Macrocentrus sp. n. *pyraustae*	Ontario
Scambus hispae (Harr.)	New Brunswick Alberta
Scambus sp. n. *pterophori*	New Brunswick
Horogenes sp.	Alberta
Exochus sp.	Ontario
Ischnus sp.	Alberta
Gravenhorstia sp.	Alberta
Ephialtes picticornis (Cress.)	Ontario
Ephialtes ontario (Cress.)	Alberta
Psychophagus tortricis (Brues)	Ontario
Chalcidoidea	
Ormyridae	
Habrocytus phycidis Ashm.	New Brunswick
Diptera	
Tachinidae	
Chaetophlepsis sp.	Alberta
Aplomya crassiseta (A. & W.)	Alberta

(Clem.), the jack-pine budworm, *Choristoneura pinus* Free., the ugly nest tortrix, *Archips cerasivorana* (Fitch), and the oblique-banded leaf roller, *Archips rosaceana* (Harr.).

Diseases

Numbers of dead and apparently diseased larvae of *C. conflictana* were examined, but no virus disease was isolated from the specimens. Larvae in their hibernacula were infected by the fungus *Beauveria bassiana* (Bals.) Vuill. In the fall of 1952, at Grenfell, Saskatchewan, 25 per cent of the hibernating larvae were killed by this disease. According to MacLeod (1953) strains of *B. bassiana* have been isolated from numerous insect species in North America, but conditions that determine the occurrence and spread of the disease are not fully understood.

Predators

Two species of ants, *Formica fusca* Linn. and *Formica sanguinea subnuda* Emery, have been observed attacking small larvae of *C. conflictana*. *F. fusca* was found foraging on the trunks of trembling aspen, and attacking larvae as they emerged from hibernation and ascended the trees in early spring. This same species was reported by Green (1950) as attacking small larvae of *Malacosoma disstria* Hbn. *F. sanguinea subnuda* was observed foraging in the tree crowns and attacking first-instar larvae in the late summer.

Criddle (1918) listed a number of bird predators of *C. conflictana* in southern Manitoba. The downy woodpecker and the red-eyed vireo were the only common species observed in outbreak areas during the present studies.

SUMMARY

A study of the life history and some aspects of the ecology of the large aspen tortrix, *Choristoneura conflictana* (Wlkr.) (n. comb.), was conducted in northern Manitoba and Saskatchewan from 1951 to 1954. The insect occurs in North America throughout the range of its principal host tree, *Populus tremuloides* Michx.

The various stages in the life history are briefly described, with more detailed descriptions of the fifth-instar larva and adult.

The eggs are laid in flat clusters on the aspen leaves from mid-June to early July, and the larvae hatch 7 to 10 days after oviposition. The first-instar larvae are gregarious, gathering between flat surfaces of leaves webbed together. The larvae skeletonize the foliage, but feeding damage is not conspicuous at this stage. Evidence obtained to date indicates that during the latter part of August the larvae descend to the base of the trunk to overwinter in hibernacula. Second-instar larvae emerge from hibernation in early May. They ascend the trees, mine the swelling aspen buds and again feed on epidermal leaf tissue. From the latter part of the third-instar until pupation, the larvae feed within rolled leaves, eating whole portions of the leaves attacked. It is during this period of larval development that the heaviest defoliation occurs. The larvae pupate from early June to mid-June; the adults emerge seven to 14 days later.

Spring larval populations may be estimated by counting infested buds and developing leaf clusters.

The large aspen tortrix has an extensive complement of parasites, many of which attack other common forest insects. A number of bird predators and two species of ants have been observed attacking the larvae. In one area, hibernating second-instar larvae were infected by the fungus, *Beauveria bassiana* (Bals.) Vuill. The true status of the disease as a control factor is not fully understood.

ACKNOWLEDGMENTS

The writer is grateful to his colleagues at the Forest Biology Laboratory, Winnipeg, and to A. C. Hodson, University of Minnesota, who aided in the development of this study and assisted in editing the manuscript.

Thanks are extended to members of the Systematic Unit, Division of Entomology, Ottawa, for identification of the parasites and predators.

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Stark, R. W. 1952. Analysis of a population sampling method for the lodgepole needle miner in the Canadian Rocky Mountain Parks. *Can. Ent.* 84: 316-321.

Twinn, C. R. 1935. A summary of insect conditions in Canada in 1935. *66th Ann. Rept. Ent. Soc. Ontario*, pp. 81-93.

Walker, F. 1863. List Lep. Het. Brit. Mus. IV. North American Tortricidae. 10.

Whitehouse, F. C. 1920. Ann. Rept. Can. Dept. Agr., Ottawa. pp. 127-129.

Distributional Records of North American Corixidae (Hemiptera: Heteroptera)

By I. Lansbury, F.R.E.S.

During 1954, I had the opportunity of examining a large collection, circa 3,500 of unidentified Corixidae which had been accumulated in the Canadian Department of Agriculture over a period of years. These notes consist of a list of species identified, with observations where pertinent when these records are new state or country records compared with the full lists of localities given in H. B. Hungerford's 'The Corixidae of the Western Hemisphere' 1948, Univ. Kansas Sci. Bull. Vol. XXXII, pp. 1-827.

Corixinae **Enderlein**

Glaenocorinisi **Hungerford**

Glaenocorisa quadrata **Walley**

1930. Can. Ent., Vol. LXII, p. 80-81, Pl. 10, figs. 10-13.
Canada, Quebec, Burnt Creek, 8.vii.1948.

Dasycorixa johanseni **(Walley)**

1931. Can. Ent. Vol. LXIII, pp. 238-239, figs. 1-5.
Canada, Manitoba, Kettle River, 7.iv.1949. J. B. Wallis.

Dasycorixa hybrida **(Hungerford)**

1926. Can. Ent., Vol. LVIII, p. 271, Pl. figs. 3 and 6.
Canada, Alberta, Edmonton, 8.v.1923. E. H. Strickland. This is the first record from Alberta.

Corixini **Walton**

Corisella edulis **(Champion)**

1901. Biol. Centr. Amer. Heter. II, p. 380, Pl. XXII, fig. 24.
U.S.A., Texas, Westlaco, 11.x.1930. J. H. Clarke.

Corisella inscripta **(Uhler)**

1894. Proc. Calif. Acad. Sci. (ser. 2), IV p. 294,
U.S.A., Oregon, Corvallis, 8.ix.1932. R. E. Dimick.

Corisella decolor **(Uhler)**

1871. American Jl. Science, ser. 3. I, p. 106.
U.S.A., California, Lone Pine, Inya County, 10.vi.1937. C. D. Michener.

Trichocorixa borealis **Sailer in Hungerford**

1948. Univ. Kansas Sci. Bull. Vol. XXXII, p. 308-310.
Canada, Quebec, Knowlton Lodge, 2. & 10. vii. 1927. G. S. Walley.
Canada, Quebec, Knowlton Lindinia?, 18.vi.1928 G. H. Fisk.
Canada, Quebec, Aylmer, 7.iv.1927. G. S. Walley.
Canada, Ontario, Ottawa, 16.iv.1927. G. S. Walley.
Canada, Ontario, Black Rapids, 27.iv.–25.vii.-1927. G. S. Walley.
Canada, Ontario, Britannia. 17.v., 10.vi.1927. G. S. Walley.
Canada, Ontario, Britannia. 3.v.1928. J. A. Adams.
Canada, Ontario, Britannia. 21.viii.1927, 14.ix.1927. W. J. Brown.
Canada, Ontario, Minaki, 30.vi.1928. J. McDunnough.
Canada, Ontario, Arnprior, 15.ix.1928. G. S. Walley.
U.S.A., Iowa, Spirit Lake. 13.v.1927. G. S. Walley.
Not recorded from Quebec or Ontario before.

Trichocorixa calva **(Say), n. comb.**

1831. Description of New Species of Heteropterous Hemiptera of North America, p. 38, in Say's Entomology, Le Conte, Vol. 1, p. 366.
Canada, Ontario, Leamington, 6.vii.1931. G. S. Walley.

U.S.A., Colorado, Boulder, 5.x.1935. T. N. Freeman.
Apparently not recorded from Canada before, the Colorado record is also new.

Trichocorixa verticalis interiores Sailer in Hungerford

1948. Univ. Kansas Sci. Bull. Vol. XXXII, pp. 354-356.
Canada, Manitoba, Fort Churchill, viii.1929. F. Johansen.

Trichocorixa naias (Kirkaldy)

1901. *Corixa sexlineata* Champion, G. C. Rhynchota Hemiptera II, Biol. Centr. Amer. p. 379.
1908. *Arctocorisa naias* n. nom. Kirkaldy, G. W. & Bueno, J. R. de la Torre, Proc. Wash. Ent. Soc. Vol. 10. p. 196.
Canada, Ontario, Ottawa, 16.ix.1927. W. J. Brown.
Canada, Ontario, Chesley Lake, 23.viii.1928. G. S. Walley.
Canada, Ontario, Delia, 2.vii.1931. G. S. Walley.
Canada, Ontario, Toronto, 3.x.1929. L. J. Milne.
Canada, Quebec, Kazubazua, 18.viii.1931. G. S. Walley.
Canada, Quebec, Misiquoi Bay, 2.vi.1931. G. S. Walley.
Canada, Quebec, Kirk's Ferry, P.Q. (light trap), 10.viii.1950. B. P. Beirne.
Canada, Alberta, Delta, 23.viii.1926. N. Criddle.
Not recorded from Quebec before.

Trichocorixa uhleri Sailer in Hungerford

1948. Univ. Kansas Sci. Bull. Vol. XXXII, pp. 348-350.
U.S.A., Texas, Weslaco, 11.x.1930. J. H. Clarke.

Trichocorixa minima (Abbott)

1913. Bull. Brooklyn Ent. Soc. Vol. VIII. No. 6, pp. 86-87, fig. 3.
U.S.A., Florida, Homestead, 28.iii.1952. J. R. Vockeroth.

Callicorixa audeni Hungerford

1928. Can. Ent., Vol. XL, p. 229, Pl. 18, figs. 6 and 12.
Canada, Quebec, Kazubazua, 28.viii.1928, 20.viii.1927. W. J. Brown and G. H. Fisk., 18.viii.1931. G. S. Walley.
Canada, Quebec, Bradore Bay, 9.viii.1930. W. J. Brown.
Canada, Quebec, James Bay East, 6.ix.1926. T. Hansen.
Canada, Quebec, Mt. Lyall, 1'500 feet, 15.viii.1932. W. J. Brown.
Canada, Manitoba, Aweme, 1.viii.1930. N. Criddle.
Canada, Manitoba, Aweme, 11.v.1930. R. H. Handford.
Canada, Manitoba, Treesbank, 1.v.1930. R. H. Handford.
Canada, Manitoba, Treesbank, 3.iv.1930. R. M. White.
Canada, Manitoba, Gillam, 10.vi.1950. J. F. MacAlpine.
Canada, Alberta, Medicine Hat, 20.v.1930. J. H. Pepper.
Canada, Alberta, Medicine Hat, 20.v.1930. J. H. Pepper.
Canada, Alberta, Lethbridge, various dates in v.1930. J. H. Pepper.
Canada, Alberta, Lethbridge, 25.v.1921. W. J. Brown.
Canada, Alberta, Waterways, 29.vii.1948. W. J. Brown.
Canada, Alberta, New Dayton, 10.vii.1921. W. J. Brown.
Canada, Alberta, Blairmore, 5.ix. ???
Canada, Alberta, McMurray, 21.vi.1953. W. J. Brown.
Canada, Alberta, Waterton Lakes, 2.vii.1930. J. H. Pepper.
Canada, Alberta, Orkney, 1.viii.1933. C. W. Farstad.
Canada, Saskatchewan, Saskatoon, 11.v.1923. N. J. Atkinson.
Canada, Saskatchewan, Saskatoon, 1.v.1940. A. R. Brooks.
Canada, Saskatchewan, Saskatoon, 15.v.1933. K. M. King.
Canada, Saskatchewan, Swift Current, 17.ix.1942. A. R. Brooks.
Canada, Saskatchewan, Asquith, 20.v.1940. A. R. Brooks.

Canada, Saskatchewan, Cut Knife, 27.viii.1940. A. R. Brooks.
Canada, British Columbia, Paxton Valley, 24.viii.1932. A. Thurr.
Canada, British Columbia, Oliver ?????.
Canada, British Columbia, Edmonton, 6.v.1924.
Canada, British Columbia, Revelstoke ?????.
Canada, British Columbia, Keremeos, 27.vii.1923. C. C. Loan.
Canada, British Columbia, West Bank, 21.iv.1952. A. N. Gartrell.
Canada, British Columbia, Nicola, 3.viii.1922. P. N. Vroom.
Canada, British Columbia, Jesmand, 18.vii.1928. J. K. Jacob.
Canada, British Columbia, Williams Lake, 13.vii.1928. G. S. Walley.
Canada, Ontario, Bell's Corners, 20.iv.1951. E. H. Strickland.
Canada, Yukon Territory, Rampart House, 21.v.1951. J. E. H. Martin.
Canada, Yukon Territory, Rampart House, 12.v.1951. C. C. Loan.
Canada, North West Territory, Norman Wells, various dates in vi. 1949. S. D. Hicks.
Canada, North West Territory, Yellowknife, 4.viii.1949. S. D. Hicks.
Canada, North West Territory, Fort Smith, 9.vii.1930. N. G. Halps.
Newfoundland, St. John's, 12.vii.1949. W. J. Brown.
Newfoundland, Gander, 28.vi.1949. R. A. Finnigan.
Newfoundland, Harmon Field, 2.vi.1949. F. G. D.
U.S.A., Colorado, Hudson, 28.viii.1923. C. J. Drake.
U.S.A., Colorado, Pingree Peak, 20.viii.1925. C. J. Drake.

Callicorixa alaskensis Hungerford

1926. Annals Ent. Soc. Amer. Vol. XIX, p. 462, Pl. XXXIV, figs. 6 and 8.
Canada, Quebec, Thunder River, various dates in 1930, W. J. Brown.
Canada, Quebec, Bradore Bay, various dates in 1930, W. J. Brown.
Canada, Quebec, Great Whale River, 25. vii. 1949. J. R. Vockeroth.
Canada, Manitoba, Churchill, 24.vi.1937. W. J. Brown.
Canada, Manitoba, Churchill, 10.viii.1937. W. J. Brown.
Canada, Alberta, Peace River District, Smoke River, 14.x.1932. L. S. Russell.
Canada, Yukon Territory, Rampart House, 21.v.1951. J. E. H. Martin.
Canada, Yukon Territory, Rampart House, 12.v.1951. J. E. H. Martin.
Canada, North West Territory, Fort Smith, 11.vi.1950. J. B. Wallis.
Canada, North West Territory, Reindeer Depot, MacKenzie Delta, 28.vi.1948. W. J. Brown.
Canada, Yukon Territory, Yellowknife, 4.viii.1949. S. D. Hicks.
Canada, Labrador, Goose Bay, 9.vi.1948. W. W. Judd.
C. alaskensis has not been recorded from Labrador before.

Callicorixa producta noorvikensis Hungerford

1926. Ann. Ent. Soc. Amer. XIX, p. 462, Pl. XXIV, figs. 4 and 7.
Canada, Manitoba, Churchill, various dates in 1937, W. J. Brown.
Canada, North West Territory, Reindeer Depot, MacKenzie Delta, various dates in 1948, W. J. Brown.
C. producta noorvikensis has not been recorded from the North West Territory before.

Hesperocorixa atopodonta (Hungerford)

1916. *Arctocorisa dubia* Abbott, J. F. Ent. News, XXVII, p. 342.
1927. *Artocorixa atopodonta* Hungerford, H. B. Bull. Brooklyn Ent. Soc., Vol. XXII, p. 35. nom. nov. for *A. dubia*.
Canada, Quebec, Port Quebec, Kirk's Ferry, 'at light', 10.viii.1951. B. P. Beirne.
Canada, Quebec, Kazubazua, 18.viii.1931. G. S. Walley.

Canada, Ontario, Ottawa, 22.viii.1936. Ed. G. Lester.
Canada, Ontario, Ottawa, 13.v.1925. C. R. Twinn.
Canada, Ontario, Toronto, 13.v.1930. L. J. Milne.
Canada, Ontario, Ventnor, 17.vii.1928. J. A. Adams.
Canada, Ontario, Black Rapids, 15.xi.1928. G. S. Walley.
Canada, Ontario, Merivale, 14.v.1930. G. S. Walley.
Canada, Ontario, Fairy Lake, various dates in 1927-'28. W. J. Brown and G. S. Walley.
Canada, Ontario, Mer Bleue, 13.viii.1936. F. A. Urquhart.
Canada, Ontario, Hog's Back, 30.iv.1936. Ed. G. Lester.
Canada, Ontario, Bell's Corners, 28.vii.1948. S. D. Hicks.
Canada, Ontario, Rockliffe, 2.vii.1928. G. H. Fisk.
Canada, Manitoba, Aweme, 3.iv.1930. R. M. White.
Canada, North West Territory, Fort Smith, 11.vi.1930. J. B. Wallis.
Newfoundland, Harmon Field, 27.v.1949. W. J. Brown.
U.S.A., Oregon, Corvallis, 20.vii.1934. H. A. Scullen.
This species has not been recorded from North West Territory and Newfoundland before.

Hesperocorixa minorella **(Hungerford)**

1926. Bull. Brooklyn Ent. Soc., Vol. XXI, p. 197, Pl. XIII, figs. 10, 12.
Newfoundland, Harmon Field, 2.vi.1949. W. J. Brown.

Hesperocorixa michiganensis **(Hungerford)**

1926. Bull. Brooklyn Ent. Soc., Vol. XXI, pp. 197-198, Pl. XIII, fig. 15.
Canada, Ontario, Ottawa, 22.viii.1936. Ed. G. Lester.
Canada, Ontario, Hog's Back, 30.iv.1936. Ed. G. Lester.
Canada, Ontario, Merivale, 14.v.1936. G. S. Walley.
Canada, Ontario, Jock River, 20.iv., 21.v.1929. G. S. Walley.
Canada, Ontario, Black Rapids, 11.v.1927. G. S. Walley.
Canada, New Brunswick, Waweig, 20.vi.1932. T. N. Freeman.
Hitherto, unrecorded from New Brunswick.

Hesperocorixa semilucida **(Walley)**

1930. Can. Ent. Vol. LXII, p. 284-285. Pl. 21, figs. 3a, b, c, d.
Canada, Ontario, Mer Bleue, 13viii.1936. F. A. Urquhart.

Hespercorixa kennicottii **(Uhler)**

1897. Trans. Maryland Acad. Sci. (Baltimore) I, p. 393-394.
Canada, Ontario, Arran Lake, 20.vi.1931. G. S. Walley.
Canada, Quebec, Knowlton, 6.vii.1929. G. S. Walley.
Not hitherto recorded from Quebec.

Hesperocorixa leavigata **(Uhler)**

1893. Proc. Ent. Soc. Wash., Vol. II, pp. 384-385.
Canada, British Columbia, Summerland, 19.x.1931. A. N. Gartrell.
Canada, British Columbia, Vernon, 26.ix.1929. W. Downes.
Canada, British Columbia, Westbank, 21.x.1932. A. N. Gartrell.
Canada, Manitoba, Aweme, 3.ix.1920. N. Criddle.
Canada, Manitoba, Aweme, 7.iv.1931. R. M. White.
Canada, Ontario, Blenheim, 26.viii.1952. B. P. Beirne.
Canada, Alberta, Chinook, 7.ix.1929. J. H. Pepper.
Canada, Saskatchewan, Swift Current, 12.ix.1940. A. R. Brooks.
U.S.A., Oregon, Corvallis, 11.iii.1933. J. Schuh.
U.S.A., Oregon, Corvallis, 20.vii.1934. H. A. Scullen.
U.S.A., Oregon, Portland, 9.viii.1952. R. E. Dimick.

Hesperocorixa vulgaris (Hungerford)

1925. Bull. Brooklyn Ent. Soc. Vol. XX, pp. 143-144, Pl. VI, fis. 1-2.
Canada, Ontario, Hog's Back, various dates in 1936, Ed. G. Lester.
Canada, Ontario, Black Rapids, 11.v.1927. G. S. Walley.
Canada, Ontario, Merivale, 14.v.1930. G. S. Walley.
Canada, Ontario, Toton, 10.iv.1930. L. J. Milne.
Canada, Quebec, Fairy Lake, 7.viii.1927. G. S. Walley.
Canada, Quebec, Fairy Lake, 3.x.1928. G. S. Walley.
Canada, Quebec, Kazubazua, 16.viii.1927. G. S. Walley.
Canada, Quebec, Kazubazua, 28.viii.1928. G. H. Fisk.
Canada, Manitoba, Glen Couris, 21.ix.1922. N. Criddle.
Canada, Manitoba, Aweme, 12.ix.1922. N. Criddle.
Canada, Manitoba, Aweme, 7.iv.1931. R. M. White.
Canada, Manitoba, Wawanesa, vi.1922. E. Ellis.
Canada, Manitoba, Treesbank, 3.iv.1930. R. M. White.
Canada, Saskatchewan, Saskatoon, 18.ix.1922. K. M. King.
Canada, Saskatchewan, Swift Current, 14.ix.1940. A. R. Brooks.
Canada, British Columbia, Clinto District, Beaverdam Lake, 11.x.1943. H. B. Leech and C. V. Morgan.
Canada, British Columbia, Sooke, 19.viii.1923. K. F. Auden.
U.S.A., Oregon, Corvallis, 24.x.1933. J. Schuh.
U.S.A., Oregon, Corvallis, 20.vii.1934. H. A Scullen.
U.S.A., Oregon, Peoria, 8.viii.1924. J. E. Davies.

Cenocorixa bifida (Hungerford)

1926. Can. Ent., Vol. LVIII, p. 268, Pl. on p. 269, pp. 268, fig. 7.
Canada, British Columbia, West Banks, 21.v.1932. A. N. Gartrell.
Canada, British Columbia, Summerland, 22.x.1932. A. N. Gartrell.
Canada, British Columbia, Summerland, Fish Lake, 9.ix.1932. A. N. Gartrell.
Canada, British Columbia, Oliver, 19.x.1932. A. N. Gartrell.
Canada, British Columbia, Peachland, 7.x.1931. A. N. Gartrell.
Canada, British Columbia, Vernon, 26.ix.1929. W. Downes.
Canada, British Columbia, Hope Mt., 4'500 feet, 19.viii.1952. A. N. Gartrell.
Canada, British Columbia, Jesmand, 18.vii.1938. J. K. Jacob.
Canada, British Columbia, Minnie Lake, 22,vii.1932. N. Criddle.
Canada, British Columbia, Nicol, 3.viii.1922. P. N. Vroom.
Canada, Alberta, Medicine Hat, 7.viii.1929. J. H. Pepper.
Canada, Alberta, Lethbridge, 23.ix.1929. J. H. Pepper.
Canada, Alberta, Edmonton, 6.v.1924. O. Bryant.
Canada, Manitoba, Aweme, 7.viii.1931. R. H. Handford.

Cenocorixa dakotensis (Hungerford)

1928. Can. Ent. Vol. LX, pp. 229-230, Pl. 18, fig. 2.
Canada, Alberta, Lethbridge, 1.ii.1931. R. W. Salt.
Canada, Alberta, Tofield, 25.viii.1922. E. H. Strickland.
Canada, Manitoba, Aweme, 1.viii.1930. N. Criddle.
Canada, Saskatchewan, Saskatoon, 5.v.1923. N. J. Atkinson.
Canada, Saskatchewan, Swift Current, 12.ix.1940. A. R. Brooks.
Canada, North West Territory, Reindeer Depot, MacKenzie Delta, 12.vii.1948, J. R. Vockeroth.
U.S.A., Iowa, Spirit Lake, 18.v.1928. G. S. Walley.
Apparently not recorded from Iowa before.

Arctocorisa chanceae (Hungerford)

1927. Annals Ent. Soc. Amer. XIX, p. 462, Pl. XXXIV, figs. 2 and 5.

Canada, Quebec, Bradore Bay, 29.vii.1930. W. J. Brown.

Arctocorisa sutilis (Uhler)

Canada, Quebec, Great Whale River, 13.viii.1949. J. R. Vockeroth.
A new record for Quebec.

Arctocorisa convexa (Fieber)

1851. Species Generis Corisa, p. 37, Tab. II, fig. 23.

Canada, Manitoba, Churchill, 24.iv.1937. W. J. Brown.
Canada, Manitoba, Churchill, 10.viii.1937. W. J. Brown.
Canada, Alberta, Orkney, 1.viii.1932. C. W. Farstad.
Canada, North West Territory, Reindeer Depot, MacKenzie Delta, 12.viii.1948. J. R. Vockeroth.
Canada, North West Territory, 11.vi.1950. J. B. Wallis.

Sigara (Arctosigara) conocephala (Hungerford)

1926. Can. Ent. Vol. LVIII, p. 270, Pl. figs. 1 & 2.

Canada, Ontario, Smoky Falls, Mattagami River, 5.viii.19344. G. S. Walley.
Not recorded from Ontario before.

Sigara (Arctosigara) decoratella (Hungerford)

1926. Bull. Brooklyn Ent. Soc. Vol. XXI, p. 195, Pl. XIII figs. 3 and 4.

Canada, Quebec, North Hartley, 24.viii.1927. G. S. Walley.
Canada, Quebec, Knowlton, 6.vii.1929. L. J. Milne.
Canada, Manitoba, Aweme, 7.iv.1931. R. M. White.
Canada, Manitoba, Aweme, 1.viii.1930. N. Criddle.
Canada, Ontario, Quarry Pond, 4.v.1925. G. S. Walley.
Canada, Ontario, Black Rapids, 3.v.1927. G. S. Walley.
Canada, Ontario, Hog's Back, 30.iv.1936. Ed. G. Lester.
Canada, Alberta, Waterways, 29.viii.1948. W. J. Brown.
Canada, Alberta, Orkney, 1.viii.1932. C. W. Farstad.
Canada, North West Territory, Fort Smith, 5.vi.1950. J. B. Wallis.
Canada, North West Territory, Yellowknife, 4.viii.1949. S. D. Hicks.
Canada, Yukon Territory, 21.v.1951. E. H. Martin.
Canada, British Columbia, Oliver, 18.viii.1923. P. N. Vroom.
Canada, British Columbia, Lac-de-Jeune, Kamloops, 23.v.1933. A. C. Thrupp.
Canada, Labrador, Goose Bay, 26.viii.1948. W. F. Beckel.
Not previously recorded from Labrador.

Sigara (Artosigara) penniensis (Hungerford)

1928. Can. Ent. Vol. LX, p. 228, figs. 7 and 8.

Canada, Quebec, Knowlton, 6.vii.1927. G. S. Walley.
Canada, Quebec, Fairy Lake, 2.x.1927. W. J. Brown.
Canada, Yukon Territory Watson Lake, 17.vi.1948. Mason and Hughes.

Sigara (Arctosigara) bicoloripennis (Walley)

1936. Can. Ent. Vol. LXVIII, p. 55, Pl. 2, figs. 5, 10.

Canada, Manitoba, Aweme, 1.viii.1930. N. Criddle.
Canada, Manitoba, Treesbank, 18.x.1930. R. H. Handford.
Canada, Ontario, Smoky Falls, Mattagami River, 5.vii.1934. G. S. Walley.

Sigara (Subsigara) fallenoidea (Hungerford)

1926. Can. Ent. Vol. LVIII, p. 270, Pl. fig. 8.

Canada, North West Territory, Yellowknife, Kam Lake, 13.vi.1949. R. H. Handford.
Not recorded from the North West Territory before.

Sigara (Lasiosigara) lineata (Forster)

1771. Novae Insectorum Centuria I, p. 70.

Canada, Quebec, Aylmer, 7.vi.1927. G. S. Walley.

Sigara (Lasiosigara) trilineata (Provancher)

1872. Naturaliste Canadien Vol. IV, p. 108.

Canada, Ontario, Minaki, various dates in 1928. J. Dunnough.
Canada, Ontario, Britannia, various dates in 1927. G. S. Walley.

Sigara (Vermicorixa) alternata (Say)

1825. Jl. Acad. Na. Sci. Phila., Vol. IV, p. 329.

Canada, Quebec, Fairy Lake, 11.ix.1928. G. S. Walley.
Canada, Quebec, Fairy Lake, 9.ix.1927. W. J. Brown.
Canada, Quebec, St. Chrysostome, 28.vi.1928. G. S. Walley.
Canada, Ontario, Black Rapids, various dates in 1927, '28. G. S. Walley.
Canada, Ontario, Mer Bleue, 13.vii.1935. F. A. Urquart.
Canada, Ontario, Ottawa, Quarry Pond, 4.v.1930. G. S. Walley.
Canada, Ontario, Ottawa, 24.viii.1936. Ed. G. Lester.
Odd specimens from Manitoba, Aweme and Treesbank; Quebec, Missiquoi, Covey Hill; Ontario, Strathroy and Hog's Back.
U.S.A., Kansas, Lawrence, iv.1930. L. W. Brown.
U.S.A., Kansas, Douglas County, 28.iii.1930. W. J. Brown.
U.S.A., Iowa, Ames, various dates in 1928. G. S. Walley.

Sigara (Vermicorixa) washingtonensis (Hungerford)

1948. Univ. Kansas Sci. Bull. Vol. XXXII, pp. 673-676, Pl. XCIII, figs. 6, 6a, 6b; Pl. XCIV, fig. 25.

Canada, British Columbia, Oliver, 31.x.1932. A. N. Gartrell.
Canada, British Columbia, Vernon, 26.ix.1929. W. Downes.

Sigara (Vermicorixa) mathesoni (Hungerford)

1917. _Arctocorisa scabra_ Parshley, Occ. Papers Boston Soc. Nat. Hist., Vol. VII, p. 119 (in part, which see)
1948. Univ. Kansas Sci. Bull. Vol. XXXII, p. 683-685, Pl. XCIII, figs. 3, 3a-3b.

Canada, Ontario, Toronto, 5.iv.1930. L. J. Milne.
Canada, Alberta, Crows Nest Pass, 27.vi.1930. J. H. Pepper.
Not previously recorded from either of these states.

Sigara (Vermicorixa) solensis (Hungerford)

1926. Bull. Brooklyn Ent. Soc. Vol. XXI, p. 198, Pl. XIII, figs. 4 and 13.

Canada, Quebec, North Hartley, 24.vii.1929. G. S. Walley.
Canada, Quebec, Knowlton, 8.vii.1929. G. S. Walley.
Canada, Quebec, Fairy Lake, various dates v.1927. G. S. Walley and W. J. Brown.
Not recorded from Quebec before.

Sigara (Vermicorixa) transfigurata (Walley)

1930. Can. Ent., Vol. LXII, No. 12, pp. 282, 285, Pl. XXI, figs. 2a-2d.

Canada, Ontario, Miner's Bay, 26.v.1931. G. S. Walley.

Sigara (Vermicorixa) mullettensis (Hungerford)

1928. Can. Ent., Vol. LX, p. 230, figs. 10-11.

Canada, Quebec, Fairy Lake, 11.ix.1928. G. S. Walley.

Sigara (Vermicorixa) knighti (Hungerford)

1948. Univ. Kansas Sci. Bull., Vol. XXXI, pp. 695-696, Pl. XCV, figs. 1, 1a and 1b.

Canada, Quebec, Kazubazua, 18.viii.1927. G. S. Walley.
This species has not been recorded from Canada before.

Sigara (Vermicorixa) hubbelli (Hungerford)

1928. Can. Ent., Vol. LX, pp. 228-229, Pl. 18, figs. 14, 15 and 16.

U.S.A., Missouri, Meridian, 5.vi.1928. M. H. Brunson.
U.S.A., West Virginia, Parsons, viii.1924.
U.S.A., Morganstown, viii.1924.

Sigara (Vermicorixa) omani **(Hungerford)**

1930. Pan-Pac. Ent., Vol. VII, No. 1, p. 25, figs. 3 and 4.
Canada, British Columbia, Metchosin, 30.viii.1929. W. Downes.
U.S.A., Oregon, Corvallis, 27.vi.1925. W. Downes.
U.S.A., Oregon, Corvallis, 5.vii.1929. H. A. Scullen and J. E. Davis.
U.S.A., Oregon, Corvallis, 24.x.1933. J. Schuh.

Sigara (Vermicorixa) pectenata **(Abbott)**

1913. Bull. Brooklyn Ent. Soc., Vol. VIII, p. 83.
U.S.A., Missouri, Meridian, 5.vi.1928. M. H. Brunson.

Sigara (Phaeosigara) variablis **(Hungerford)**

1926. Bull. Brooklyn Ent. Soc., Vol. XXI, pp. 198-199, figs. 2 and 7.
Canada, Ontario, Black Rapids, 5.xi.1928. G. S. Walley.
Canada, Ontario, Leamington, 6.vii.1931. G. S. Walley.
Canada, Ontario, Chesley Lake, 23.viii.1928. G. S. Walley.
Canada, Ontario, Ottawa, 21.v.1928. W. J. Brown.
Canada, Quebec, Knowlton, vii.1929. G. S. Walley.
Canada, Quebec, North Hartley, 24.vii.1929. G. S. Walley.

Sigara (Phaeosigara) compressoidea **(Hungerford)**

1928. Can. Ent., Vol. LX, p. 226, Pl. 18, figs, 9 and 13.
Canada, Quebec, Kazubazua, 22.vii.1927. W. J. Brown.
Canada, Quebec, Kazubazua, 20.vii.1927. G. S. Walley.

Sigara (Phaeosigara) mackinacensis **(Hungerford)**

1928. Can. Ent., Vol. LX, p. 228, Pl. 18, figs. 1 and 4.
Canada, Ontario, Chesley Lake, 23.viii.1928. G. S. Walley.
Canada, Ontario, Arran Lake, 20.vi.1931. G. S. Walley.

Sigara (Phaeosigara) macropala **(Hungerford)**

1926. Bull. Brooklyn Ent. Soc., Vol. XXI, pp. 196-197, figs. 6, 9 and 11.
Newfoundland, Harmon Field, 28.v.1949. W. J. Brown.
Not recorded from Newfoundland before.

Sigara (Phaeosigara) signata **(Fieber)**

1851. Species Generis Corisa, p. 21, Tab. 1, fig. 16.
Canada, Quebec, Kazubazua, 20.vii.1927. G. S. Walley.
Canada, Quebec, Knowlton, vii.1929. G. S. Walley.
Canada, Labrador, Goose Bay, 9.vii.1948. H. C. Friesen.
Not recorded from any of the-mentioned localities before.

Sigara (Phaeosigara) dolabra **(Hungerford and Sailer)**

1942. Bull. Brooklyn Ent. Soc., Vol. XXXVII, No. 5, pp. 170-180, 1 pl.
Newfoundland, Harmon Field, 2.vi.1949. W. J. Brown.
Not recorded from Newfoundland before.

Cymatiinae **Hungerford**

Cymatia americana **Hussey**

1920. Bull. Brooklyn Ent. Soc. Vol. XV, pp. 80-83, Pl. 1.
Canada, North West Territory, 26 miles west of Fort Smith, 2.vii.1953. J. B. Wallis.

Acknowledgements

Acknowledgements are extended to Dr. B. P. Beirne and Dr. L. A. Kelton for arranging the shipment of the Corixidae from the Canadian Department of Agriculture and for much other assistance freely given.

(Received August 25, 1955)

A Secondary Sex Character on the Male of the California Five-spined Engraver, *Ips confusus* (Lec.) (Coleoptera: Scolytidae)[1]

By R. L. LYON[2]

A study of 2,500 adults of the California five-spined engraver, *Ips confusus* (Lec.), has shown that the sex of this beetle can be determined from a secondary sex character with an accuracy exceeding 99 percent. Insects often have secondary characters that indicate sex, and in species with concealed genitalia, reliable secondary characters are especially useful for rapidly separating the males and females. Where such characters are lacking, a dependable determination of sex can only be made by the laborious procedure of dissection for a check of genitalia.

Exterior differences between the sexes of the California five-spined engraver are subtle and usually considered inconsistent. In the original description of this species (then *Tomicus confusus*) by Leconte (*2*), separative characters were not given. Although *Ips confusus* was not mentioned, Hopkins (*1*) indicated that some species of the genus *Ips* show a stronger development of declivital spines in the male, while in others the male may have a "frontal tubercle." Struble (*3*) applied the former characteristic to distinguish sex in *Ips confusus*, in which the third spine is larger in the males, but he added that fixing sex on this basis would result in a 15 percent error. Thatcher (*4*) stated that *Ips confusus* has an "epistomal tubercle," but did not indicate its reliability in separating sexes. He determined the sex of a group of 94 *Ips confusus* adults with 99 percent accuracy by "frontal characters," but did not specifically report the use of the epistomal tubercle.

The separative character found in the present study is an enlarged tubercle on the frons, situated medially and just above the epistomal margin in the male (fig. 1A). The shape of the tubercle is not consistent. It is usually conical (with rounded apex) to hemispherical, but in occasional males is truncated and so irregular as to have no definite form. In all beetles observed, however, the sides of the tubercle rose steeply, and thus this structure could be easily distinguished from a similarly positioned and gently sloped cuticular embossment often found in females (fig. 1B). The tubercle as illustrated in figure 1A, projects directly away from and perpendicular to the frons, but it was frequently found to angle downward toward the mandibles. Its location was consistent: always medial and contiguous, or nearly so, with the epistomal border. The tubercle was usually greater than twice the size of the frontal asperites, but ranged from about the same size to more than five times as large.

The 2,500 adults studied were reared from ponderosa pine (*Pinus ponderosa* Laws.). Internal genitalia of 350 beetles were examined to confirm the reliability of this character as an indicator of sex. From this group, two females were found to have a rudimentary tubercle corresponding in size with the smallest ones found in the males.

The remaining 2,150 beetles were separated according to the presence or absence of the tubercle, except when the tubercle was as small as the rudimentary forms seen in occasional females. Then, internal genitalia were examined to confirm sex. Tubercles on 15 beetles fell in this small size range, but only 2 were females. It is evident from the sample tested that the tubercle is an unreliable

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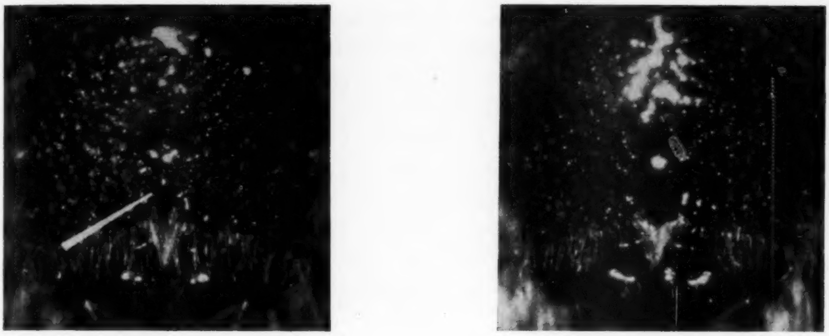
[1]Contribution from the Division of Forest Insect Research, California Forest and Range Experiment Station, which is maintained by the Forest Service, U.S. Department of Agriculture, at Berkeley, California, in cooperation with the University of California.

[2]Entomologist, California Forest and Range Experiment Station, Berkeley, California.



A B

Fig. 1. Front view of head of *Ips confusus* (Lec.) showing: A. Front of male with tubercle (pointer) characteristic of this sex (X55); B. Front of female with tubercle absent or rudimentary (X55).

indicator of sex if it is but slightly larger than the many asperites scattered uniformly about the front and sides of the head. Suspicion that the beetle may be female is justified, therefore, when the tubercle is of such a size. For confirmation, genitalia should be examined.

When lighting is adequate, a 14x hand lens is satisfactory for determining the sex of *Ips confusus* adults from this secondary character, but a 20 to 25 magnification is better.

Literature Cited

1. Hopkins, A. D. 1894. Sexual characters in Scolytidae. Can. Ent. 26: 274-280.
2. LeConte, J. L. and G. H. Horn. 1876. The Rhynchophora of America, North of Mexico. Proc. Am. Philos. Soc. 15(96): p. 364.
3. Struble, G. R. 1947. A study of factors in the development of *Ips* outbreaks. Manuscript Report, Forest Insect Laboratory, Berkeley, Calif. p. 6.
4. Thatcher, T. O. 1948. A taxonomic and biologic study of the genus *Ips* (Scolytidae, Coleoptera) in western North America. Univ. of Calif. Ph.D. thesis, pp. 1-150.

New Species of *Liocoris* from North America (Hemiptera: Miridae)[1]

By Leonard A. Kelton[2]

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Ottawa, Canada

The extensive literature on the "lygus" bugs of economic importance in North America deals with members of the genus *Liocoris* Fieber (Kelton, 1955). In this paper four new species that formerly were misidentified as other species of the genus *Lygus* Hahn are described.

Liocoris rufidorsus n. sp

Figs. 1, 5

?*Lygus pratensis* var. *oblineatus*, Knight, 1917: 564.
?*Lygus hesperus*, Salt, 1945: 573.

Male:—length 5.88 mm., width 2.7 mm. Head: width, 1.13 mm.; width of vertex between eyes, 0.49 mm.; length, 0.91 mm.; head yellow; median, submedian, and lateral vittae of frons reddish-brown (Fig. 12); middle of tylus and a vitta on gena extending to the lower margin of eye, reddish. Rostrum 2.17 mm. long, reaching hind coxa. Antenna: I, 0.57 mm. long, reddish-brown with lower side brown; II, 1.61 mm., reddish-brown, base and apex black; III, 0.94 mm., black; IV, 0.77 mm., black. Pronotum: length, 1.13 mm.; width at base, 2.24 mm.; greenish-yellow, very shiny; calli yellow, with two black spots behind each usually extending as black rays toward middle of disc, and a black ray behind the anterior angle extending along the lateral margin; side of pronotum with a black spot and a brown dash above the coxal cleft; pronotum irregularly punctate, pubescence very short; calli margined behind and between by an impressed groove; mesoscutellum black, lateral areas reddish; scutellum yellow, with a reddish-brown V at each side of mid line. Hemelytra: greenish-yellow intermixed with reddish-brown, the apical halves of corium and embolium reddish-brown; cuneus pale green, basal and mesial margins reddish, tip reddish-brown; membrane fuscous, the veins reddish; hemelytra shallowly punctuate with very short, sparse pubescence. Ventral surface: reddish-brown; sternum dark reddish-brown to black, paler at the sides; abdomen with a yellowish stripe on each side; hind femora yellowish with brown bands at their middles and two narrower bands at apices; tibia yellow, apices brown, spines black.

Female:—length 5.8 mm., width 2.8 mm., slightly smaller than the male; similar in colour but with the dark markings reduced, often obsolete.

The species is distinguished by the submedian vitta on the frons, the pale areas on the mesoscutellum near the basal angles of the scutellum, the reddish-brown colour, the very sparse and short pubescence, and the forms of the genital structures (Figs. 1, 5). It resembles *lineolaris* (Beauv.) in general appearance and in size, but is easily separated by the shorter and sparser pubescence on the

1Contribution No. 3344, Entomology Division, Science Service, Department of Agriculture, Ottawa, Canada.

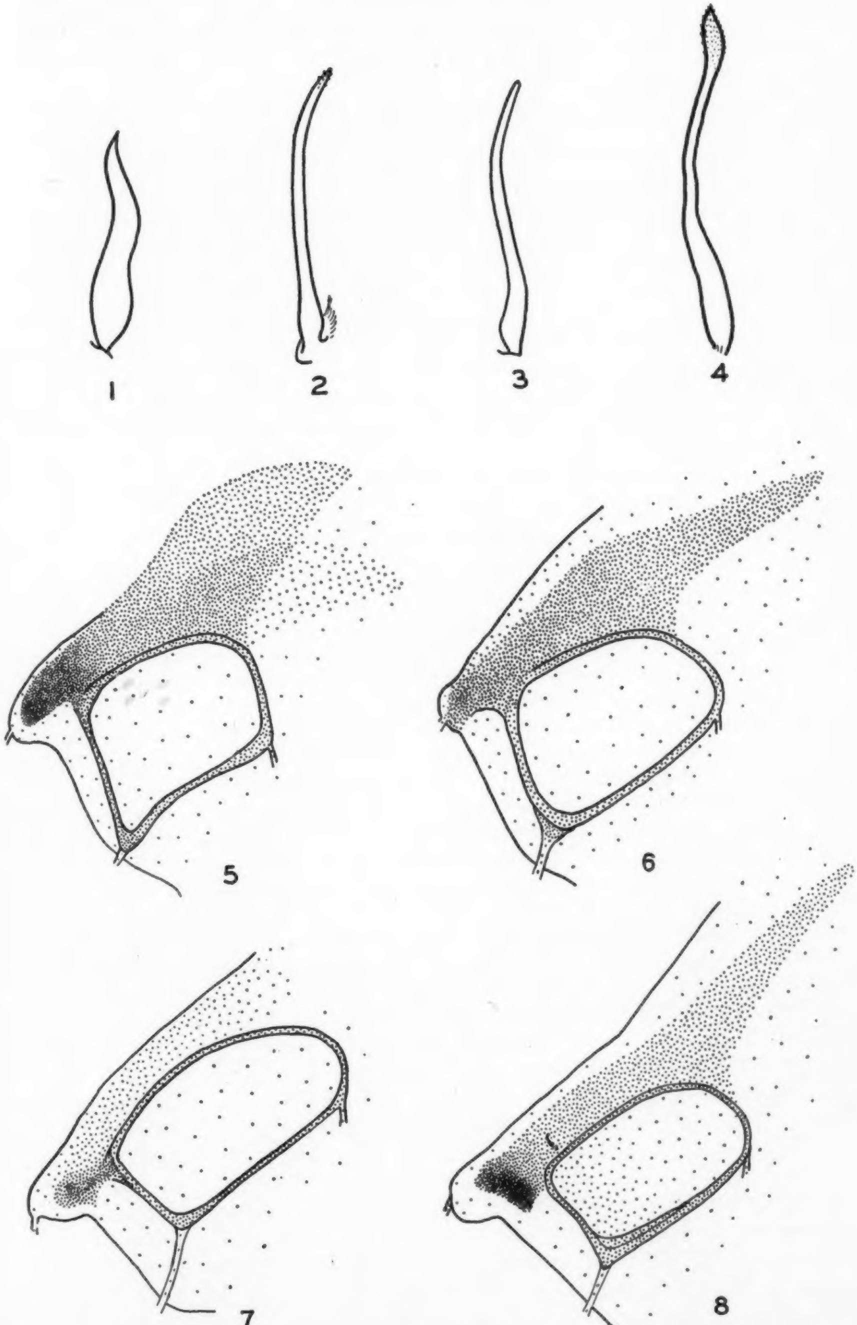
If the petition "A proposal to use the plenary powers to fix the type species of the Genus *Lygus* Hahn, 1833", by J. C. M. Carvalho, H. H. Knight, and R. L. Usinger, to the International Commission on Zoological Nomenclature is accepted, the following will be effected:—

The Genus *Liocoris* Fieb., 1858, with *Cimex tripustulatus* F. as type and containing the "lygus" bugs of economic importance, including the four species described herein, will become *Lygus* Hahn, 1833, with *pratensis* (L.) as type.

2Associate Entomologist.

Figs. 1-4. Spiculum of the vesica of: 1, *Liocoris rufidorsus;* 2, *L. unctuosus;* 3, *L. borealis;* 4, *L. solidaginis.*

Figs. 5-8. Sclerotized ring of female of: 5, *Liocoris rufidorsus;* 6, *L. unctuosus;* 7, *L. borealis;* 8, *L. solidaginis.*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hemelytra: the pubescence of *rufidorus* is very short, giving the hemelytra a very shiny appearance, whereas in *lineolaris* the hemelytra are dull and hairy. Moreover, *rufidorus* has a longer second antennal segment and a shorter rostrum than that of *lineolaris.*

Holotype, ♂, White Fox, Sask., May 26, 1950 (L. A. Kelton), collected on alfalfa. No. 6070 in the Canadian National Collection, Ottawa.

Allotype, ♀, same data as holotype.

Paratypes, 20 ♂♂, 22 ♀♀, from the following localities:
ALBERTA: Elkwater, May 27 to Aug. 15; Coutts, June 15 (L. A. Kelton and A. R. Brooks, 1952). Edmonton, June 12, 1940 (H. Hurtig), and May 5, 1937 (E. H. Strickland). Cooking Lake, June 20, 1937 (F. O. Morrison). SASKATCHEWAN: White Fox, May 16 to July 4, on alfalfa; Torch River, May 16 to July 20; Garrick, July 12; Pas Trail, June 12 (L. A. Kelton, 1950). Indian Head, April 26, 1929 (K. Stewart). NEW HAMPSHIRE: Crawford House, White Mts., July 19, 1954 (J. A. Slater). Paratypes in the Canadian National Collection, Ottawa; United States National Museum, Washington, D.C.; Knight Collection, Ames, Iowa; University of Alberta, Edmonton; and the University of California, Berkeley.

Liocoris unctuosus n.sp.

Figs. 2, 6, 9, 12

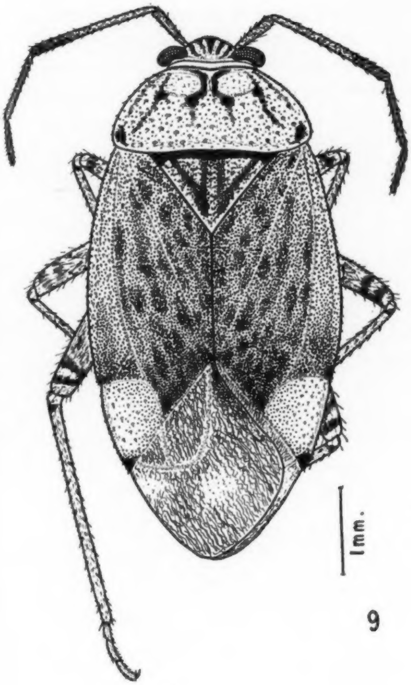
?*Lygus pratensis* var. *oblineatus,* Knight, 1917: 564.
?*Lygus hesperus,* Bolton and Peck, 1946: 130.

Male:—length 5.6 mm., width 2.8 mm. Head: width, 1.15 mm.; width of vertex between eyes, 0.49 mm.; length, 0.89 mm.; head yellowish; median, submedian, and lateral vittae of frons reddish-brown (Fig. 12); middle of jugum, margins of lora, and usually a band at tip of tylus, black. Rostrum 2.10 mm. long, reaching midway between middle and hind coxae. Antenna: I, 0.54 mm. long, yellowish with lower side dark brown; II, 1.57 mm., yellowish-brown, base and apex black; III, 0.87 mm., black; IV, 0.75 mm., black. Pronotum: length, 1.13 mm.; width at base, 2.24 mm.; yellowish-green, semitransparent; calli yellow, with two black rays behind each and usually two short black dashes between, and a black ray behind the anterior angle extending along the lateral margin; side of pronotum with two black rays across top of coxal cleft, basal angles each with a black dot; pronotum irregularly punctate, pubescence very short; mesoscutellum black; scutellum yellow, with a black V on each side of mid line. Hemelytra: pallid greenish-brown, irregularly mottled with brown, heaviest at middle of clavus and apex of corium; claval vein and cubitus pale; cuneus pallid green, mesial half fuscous, tip black; membrane fuscous, vein pale; hemelytra shallowly punctate with very short, sparse pubescence (Fig. 9). Ventral surface: blackish mixed with brown; abdomen with a yellowish stripe on each side; hind femora yellowish with two brown bands near apices.

Female:—length 5.67 mm., width 2.8 mm., very similar to male in colour but with the black markings of head and hemelytra reduced.

The species is distinguished by the submedian vitta on the frons, the black mesoscutellum, the mottled brown colour, the very short and sparse pubescecne, and the genital structures (Figs. 2, 6). It resembles *lineolaris, rufidorsus,* and *plagiatus* in the forms of markings on the head and scutellum. The colour of the hemelytra is suggestive of *plagiatus,* but the species is readily separated by the

Figs. 9-11. Adult of: 9, *Liocoris unctuosus;* 10, *L. borealis;* 11, *L. solidaginis.*
Figs. 12, 13. Head of: 12, *L. unctuosus;* 13, *L. borealis.*



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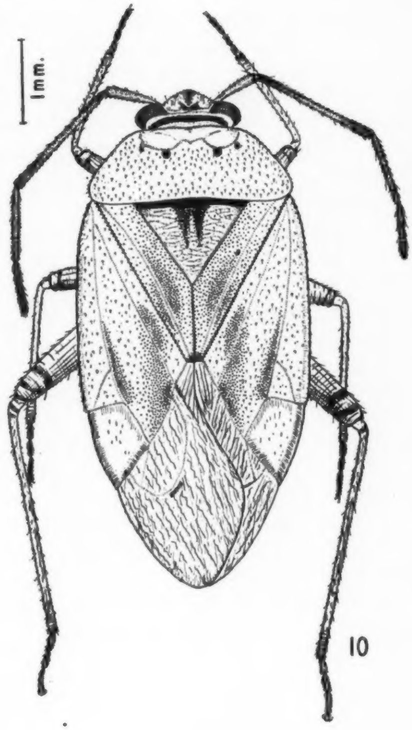

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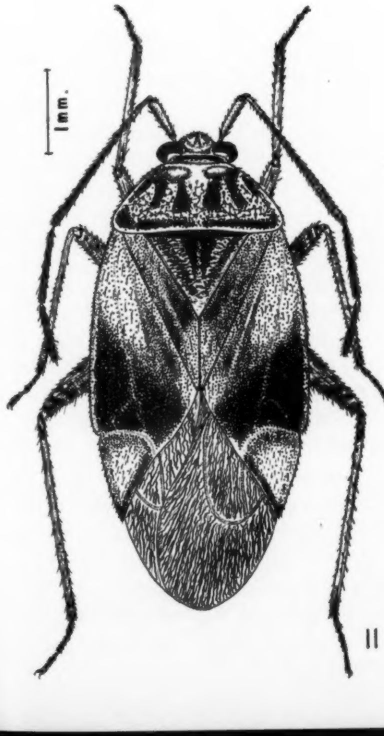

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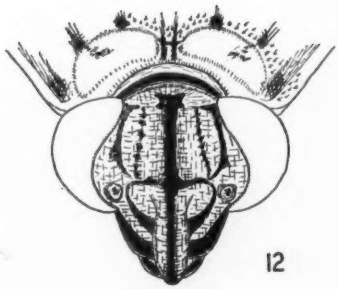

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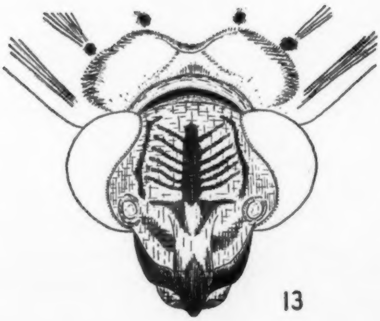

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shorter and sparser pubescence on the hemelytra: the pubescence of *unctuosus* is very short and sparse, whereas in *plagiatus* it is long and dense, and mottled with pale areas. The species is easily separated from *lineolaris* by the brown colour, the almost glabrous appearance, the black mesoscutellum, and the shorter rostrum. Generally the species is greasy in appearance.

Holotype, ♂, Torch River, Sask., July 20, 1950 (L. A. Kelton), collected on pineapple-weed, *Matricaria matricarioides*. No. 6071 in the Canadian National Collection, Ottawa.

Allotype, ♀, same data as holotype.

Paratypes, 41 ♂♂, 37 ♀♀ from the following localities:
British Columbia: Rolls, July 11, 1927 (P. N. Vroom). Alberta: Elkwater, July 8 to Aug. 20, 1952 (L. A. Kelton and A. R. Brooks). Cooking Lake, June 17 to July 11, 1937 (F. O. Morrison). Shaftsbury, Aug. 18, 1915 E. H. Strickland), Waterways, June 1, 1947 (L. G. Saunders). Saskatchewan: Torch River, May 16 to July 20; White Fox, May 25 to Aug. 15; Nipawin, June 3-5; Pas Trail, June 12 (L. A. Kelton, 1950). Waskesiu, July 22, 1939; Christopher Lake, July 9, 1950 (A. R. Brooks). Cypress Hills, Aug. 20, 1952 (L. A. Kelton). Manitoba: Aweme, Aug. 12, 1920 (N. Criddle). Mafeking, June 18, 1949 (E. C. Martin). Ontario: Moose Factory, June 16, 1949 (D. P. Whillans). Quebec: Rupert House, June 27, 1949 (D. P. Gray). Northwest Territories: Fort Simpson, July 30 to Aug. 21, 1950 (D. P. Whillans). Paratypes in the Canadian National Collection, Ottawa; United States National Museum, Washington, D.C.; Knight Collection, Ames, Iowa; University of Alberta, Edmonton; University of California, Berkeley.

Liocoris borealis n.sp.

Figs. 3, 7, 10, 13

?*Lygus pratensis*, Knight, 1925: 182.
?*Lygus elisus*, Salt, 1945, 573.

Male:—length 5.81 mm., width 2.8 mm. Head: width, 1.22 mm.; width of vertex between eyes, 0.52 mm.; length, 0.96 mm.; head yellowish-green with the following reddish: vertical line along the inner margin of each eye, and fingerlike projection on middle of frons, lora, and jugum (Fig. 13). Rostrum 2.38 mm. long, reaching posterior margin of hind coxa. Antenna: I, 0.52 mm., yellow, lower side brown; II, 1.54 mm., light reddish-brown; III, 0.91 mm., brown; IV, 0.63 mm., brown. Pronotum: length, 1.26 mm.; width at base, 2.38 mm.; anterior half yellowish, basal half greenish; calli yellow, with two black dots behind each, the outer almost obsolete, and line at middle and basal margins pale; punctures of pronotum shallow, pubescence very short; mesoscutellum black; scutellum pale yellow, with two short, median dashes at base. Hemelytra: pallid green, middle of clavus slightly darkened, claval vein light; apex of corium with a brown bar along inner cubitus and a small fuscous area at brachium; cuneus pallid green, outer margin pale; membrane pale, veins colourless; hemelytra shallowly punctate, pubescence very short. Ventral surface: reddish with black; abdomen with a pale stripe on each side; hind femora with two reddish bands near apices.

Female:—length 5.88 mm.; width 2.87 mm.; very similar to male in colour but with the red markings of head and the black markings of hemelytra reduced; ventral surface greenish rather than reddish.

The species is distinguished by the pale green colour, the very short and sparse pubescence on the hemelytra, the usual absence of a black mark at the

tip of the cuneus, the two short black dashes at the middle of the scutellum (Fig. 10), and the genital structures (Fig. 3, 7).

Holotype, ♂, White Fox, Sask., June 16, 1950 (L. A. Kelton), collected on alfalfa. No. 6072 in the Canadian National Collection, Ottawa.

Allotype, ♀, same data as holotype.

Paratypes, 73 ♂ ♂, 81 ♀ ♀ from the following localities:
ALBERTA: Elkwater, May 23 to July 23; Irvin, June 23; Onefour, June 6 to Aug. 19; Frank, June 18; Lundbreck, Aug. 25; Coutts, June 15; Milk River, June 16; Manyberries, June 21 to Aug. 22; Medicine Hat, June 2; Spring Point, June 18; Waterton Lakes, June 16, Cowley, June 18 (L. A. Kelton and A. R. Brooks, 1952). Edmonton, June 12, 1940 (H. Hurtig), and July 22, 1937 (F. O. Morrison). Lethbridge, Sept. 20, 1913 (E. H. Strickland), and June 6, 1952 (L. A. Kelton). SASKATCHEWAN: White Fox, May 16 to June 28; Nipawin, June 2-5; Torch River, May 22 to June 28; Pas Trail, June 12; Love, May 22 to June 28 (L. A. Kelton, 1950). Saskatoon, Apr. 28 to Sept. 14 (L. A. Kelton and A. R. Brooks, 1949-50). McGee, July 3, 1952 (L. A. Kelton). Pike Lake, May 5, 1939, and July 20, 1950 (A. R. Brooks). Eastend, Aug. 3, 1950 (J. C. Arrand). MANITOBA: Aweme, July 26, 1922 (R. M. White). YUKON: Rampert House, May 22, 1951 (C. C. Loan). NORTHWEST TERRITORIES: Yellowknife, Aug. 10, 1949 (E. F. Cashman). Fort Simpson, June 16, 1950 (D. P. Whillans). Reindeer Depot, Mackenzie Delta, July 2 to Aug. 13, 1948 (J. R. Vockeroth). MONTANA: Browning, Aug. 26, 1951 (L. A. Kelton). Paratypes in the Canadian National Collection, Ottawa; United States National Museum, Washington, D. C.; Knight Collection, Ames, Iowa; University of Alberta, Edmonton; University of California, Berkeley.

***Liocoris solidaginis* n.sp.**

Figs. 4, 8, 11

Male:—length 6.09 mm., width 2.8 mm. Head: width, 1.13 mm.; width of vertex between eyes, 0.45 mm.; length, 0.96 mm.; head yellowish, middle of frons reddish, a vertical line on the inner margin of each eye black. Rostrum 2.52 mm. long, reaching beyond hind coxa. Antenna: II, 0.56 mm. long, yellowish, lower side black; II, 1.71 mm., light brown, basal and apical fourths black; III, 0.87 mm., black; IV, 0.66 mm., black. Pronotum: length, 1.22 mm.; width at base, 2.38 mm.; yellowish-brown, the inner half of each callus yellow, two black rays behind each, extending toward middle of disc, and a black ray behind the anterior angle extending along the lateral margin, the area between the rays pale and the basal angles each with a rounded black spot; side of pronotum with a spot and a black dash above coxal cleft; pronotum deeply and coarsely punctate; mesoscutellum black; scutellum yellowish-brown with a reddish V at each side of mid line, tip pale yellow. Hemelytra: yellowish-brown, the corium black on the apical half along the outer margin and diagonally to the base of the brachium of the membrane (Fig. 11); embolium, cubitus, and claval vein pale; cuneus opaque, roughly rugose, with the tip and the mesial and basal margins reddish; membrane fuscous, veins yellowish; deeply and coarsely punctate, with dense, yellowish pubescence. Ventral surface: yellowish-brown, abdomen with a lateral pale stripe on each side.

Female:—length 6.0 mm., width 2.94 mm., very similar to male in appearance but with the dark markings on head, scutellum, pronotum, and cuneus somewhat reduced; ventral surface more uniformly reddish.

The hibernating adults are much darker in colour than the summer adults, being reddish-brown rather than yellowish, and the triangular colour marking

on the corium being more obscured. The scutellum is reddish-brown, with the V marks obscured. The membrane is pale, and the veins reddish. The genital structures are distinctive (Figs. 4, 8).

This species is very abundant on snowberry in the spring and on goldenrod in the fall.

Holotype, ♂, Saskatoon, Sask., Sept. 14, 1950 (L. A. Kelton), collected on goldenrod. No. 6073 in the Canadian National Collection, Ottawa.

Allotype, ♀, same data as holotype.

Paratypes, 81 ♂♂, 102 ♀♀, from the following localities: ALBERTA: Elkwater, May 27 to Aug. 15, on snowberry, *Symphoricarpos occidentalis*, and goldenrod; Irvin, July 9; Onefour, Aug. 17; Cowley, June 18, on hound's tongue, *Cynoglossum boreale*, Lundbreck, Aug. 25, on Canada thistle, *Cirsium arvense*, (L. A. Kelton and A. R. Brooks, 1952). Lethbridge, May 17 and Aug. 23, 1930 (J. H. Pepper). June 6, 1952 (L. A. Kelton and A. R. Brooks). Medicine Hat, Aug. 7, 1938 (E. H. Strickland), and Aug. 11, 1949 (B. Hocking). SASKATCHEWAN: Saskatoon, May 5 to Sept. 14, 1950, on snowberry and goldenrod; Great Sand Hills, July 4, 1952, on snowberry; Harris, July 3, 1952, on snowberry; Tisdale, Aug. 25, 1950 (L. A. Kelton and A. R. Brooks). Paratypes in the Canadian National Collection, Ottawa; United States National Museum, Washington, D.C.; Knight Collection, Ames, Iowa; University of Alberta, Edmonton; University of California, Berkeley.

Acknowledgments

Most of the material for the study was obtained from the Entomology laboratories at Lethbridge and Calgary, Alta.; Saskatoon, Sask.; and Brandon, Man.; the Canadian National Collection, Ottawa; and through the kindness of Professor E. H. Strickland, the University of Alberta, Edmonton. The writer is indebted to Dr. H. H. Knight, Iowa State College, Ames, for permission to examine the types in his private collection and for help in determinations.

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(Received August 25, 1955)

The Oak Bark Beetle, *Pseudopityophthorus minutissimus* (Zimm.) (Coleoptera, Scolytidae) and its Biology in Wisconsin[1]

By LESLIE H. MCMULLEN, EDWIN W. KING, AND ROY D. SHENEFELT[2]

Among the many insects under investigation as potential vectors of the oak wilt fungus in Wisconsin and elsewhere, the species of *Pseudopityophthorus* have attracted considerable attention. Although recent developments appear to indicate that the long-distance spread of this serious disease occurs primarily with the aid of other insects, our knowledge at present does not warrant the assumption that bark beetles play no part whatever. In the study of *P. minutissimus* from August, 1952, to the fall of 1953, considerable information concerning its biology in Wisconsin has been brought to light; and regardless of its relationship to the oak wilt problem it seems desirable at this time to make better known this member of the Wisconsin bark beetle fauna.

Pseudopityophthorus minutissimus was described in 1868 by Zimmerman under the genus *Crypturgus*. In 1918 Swaine established the genus *Pseudopityophthorus* and made *minutissimus* (Zimm.) its genotype. The group was monographed by Blackman in 1931, and at present contains about a dozen species. It is characterized by having the pronotum and elytra more densely punctate than in related genera, and by the fact that the males have a prominent brush of long yellow hairs on the front of the head. The following description of the adult of *minutissimus* is taken from Chamberlin (1939):

"A dark reddish brown species, 1.5 to 1.9 mm. long; front broad, planoconvex on a subcircular area, extending from eye to eye. Antennal club 1.75 times as long as funicle, 1.4 times as long as wide. Pronotum slightly longer than broad, feebly constricted before the middle, broadly rounded in front, margin with numerous sharp, regular serrations; anterior area strongly aspate, summit low, with a weak transverse impression; . . . declivity convex, suture narrow and feebly elevated. Female with frontal serrations and asperities finer."

Larvae of *P. minutissimus* are typical bark beetle larvae, being legless and 3-4 mm. long when fully grown. They are pale white when the digestive system is evacuated and brownish gray when its contents show through the body wall. Pupae are the size of the adults, and show no remarkable morphological features. Eggs are soft, spherical, and about 0.2 mm. in diameter.

Host Plants

Although this beetle is most commonly recorded from oak, it is recorded in literature as feeding also on *Betula, Castanea, Fagus, Hicoria, Cornus, Amelanchier, Ostrya, Carpinus,* and *Hamamelis*. In Wisconsin it has been observed on the three common species of the black oak group: *Quercus borealis, Q. ellipsoidalis,* and *O. velutina*. It has not been found breeding in white or bur oaks.

Distribution

The range of *P. minutissimus* in North America is recorded in literature as extending westward to the plains, north to Quebec, and south to Georgia. Under these conditions it is not suprising that it is distributed wherever oak occurs in Wisconsin. Figure 1 presents the points where the insect has been collected in the state during the course of this study. These points are: Lake Geneva,

1Approved for publication by the Director of the Wisconsin Agricultural Experiment Station. This work was supported in part by the National Oak Wilt Research Committee, and the Wisconsin Conservation Department, to whom grateful acknowledgment is made. We also wish to record our thanks to Dr. W. H. Anderson, U.S. Bureau of Entomology and Plant Quarantine, who made the original identification of our specimens, and to the Nekoosa-Edwards Paper Company for use of facilities and land areas.

2Research Associate, Department of Entomology, University of Wisconsin, Assistant Professor, Department of Biology, Cornell College, Iowa, and Associate Professor, Department of Entomology, University of Wisconsin, respectively.

Fig. 1. Collection points for *Pseudopityophthorus minutissimus* in Wisconsin.

Wisconsin Rapids, Plover, Westboro, Neopit, Richardson, Dickeyville, Marinette, Sturgeon Bay, Wisconsin Dells, Madison, South Wayne, and Eau Claire.

Life History and Habits

It has been established by workers in Missouri (Buchanan, personal communication) that in the central and southern parts of its range this beetle breeds continually through the winter. This apparently does not occur in Wisconsin. Branches from standing trees examined in the winter and early spring contained only the larger larvae, which seem to represent the only winter-resistant stage. These larvae mature when the hazel buds are about to break and the larch needles are about ¼″ long (in 1953, May 1). Adults remain in their galleries a week or more, then emerge. The emergence of the spring adults continues for approximately two weeks.

Upon emergence, the adults seek suitable branches for oviposition. Whether they feed externally in nature has not been definitely established. They certainly

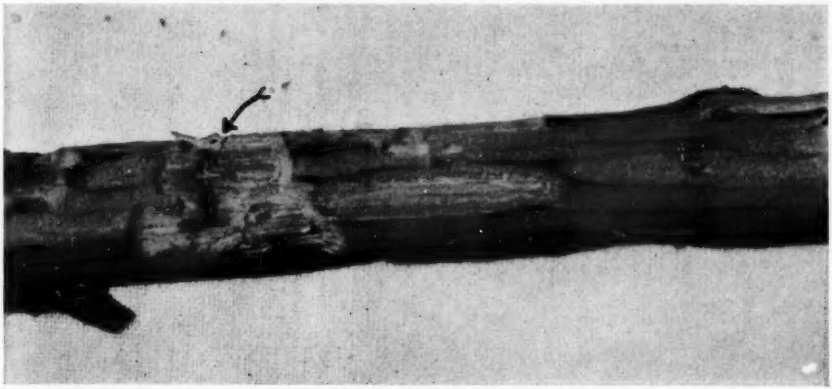

Fig. 2. Typical gallery of *P. minutissimus* exposed.

do so under cage conditions. Abortive galleries in relatively green branches have been found on several occasions, which indicates that the beetles may enter cessful galleries were from ½" to 4" in diameter but others have reported galleries before completion. Usually the branch selected is still green and perhaps leafy, but of lessened vigor and likely to die within a year. Branches found with successful galleries were from ½" to 4" in diameter but others have reported galleries in logs up to 8".

The entrance hole of a new gallery is started by the male, usually in a roughened or concealed area. The typical entrance hole turns down the limb after it reaches the xylem, and scars the xylem vertically for a distance of about 10 mm. Sometime during this operation, the male is joined by one female. After copulation, the female spends the rest of her life excavating a circumferential gallery which crosses the vertical gallery at its center and may extend 2 cm. or more on either side of it. The result is a very distinctive, cross-shaped gallery (figure 2). Along the edges of this gallery eggs are laid at the rate of about two per day. They are placed in relatively large niches and packed firmly with frass. At the close of egg laying, the female usually dies in the egg gallery, and the male is often found dead with his body blocking the entrance hole.

The egg hatches in 4-6 days, and the young larva bores away from the egg gallery, up or down with the grain of the wood. Galleries of the small larva are entirely outside the cambium layer but by the time the larva is half grown it is in the cambium, and the full-grown larva scars the xylem and breaks vessels as does the adult (figure 3). The larva works rapidly in the warm summer temperatures, and may tunnel as far as 4 or 5 cm. Pupation begins in about seven or eight weeks.

The larvae undergo several molts, the exact number of which is difficult to determine. It was not found possible to observe a single specimen for more than one molt, or to find morphological differences between the instars other than the size of the head capsule.

The head capsules of 144 specimens, collected throughout the developmental period from a single infested tree, were measured with an ocular micrometer and a compound microscope. Measurements at a magnification of 150X were made across the widest part of the head, and recorded as arbitrary units (one unit =

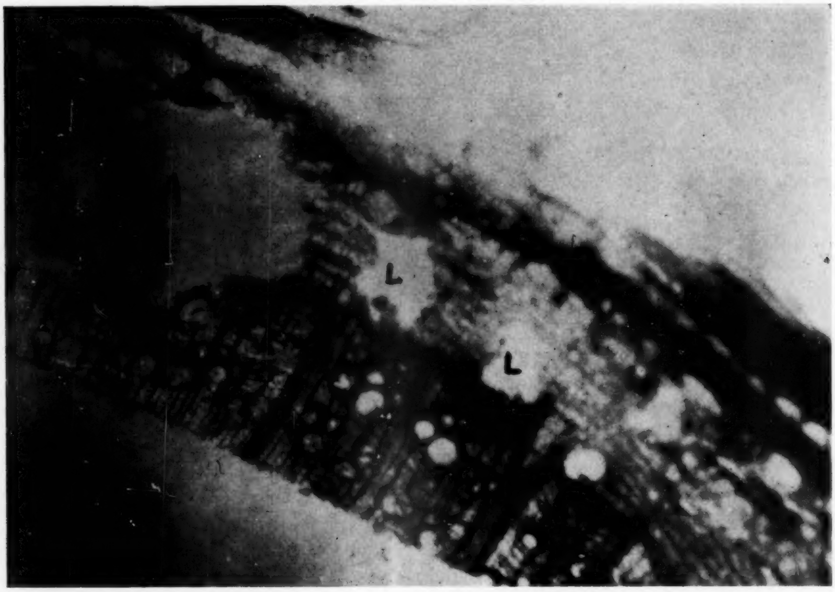

Fig. 3. Cross-section of adult (A) and larval (L) galleries of P. *minutissimus*.

approximately .01 mm.). The frequencies were plotted to produce the histogram in figure 4.

The data were analysed according to Forbes (1953). Analysis indicated five instars with modes of 17, 20.52, 26.3, 30.18, and 34, and with standard deviations of 1.8, 1.3, 2.3, 1.7 and 1.5 respectively. However, the actual class values obtained deviate considerably from those expected from the results of the above analysis ($X^2 = 23.4$ for 7 df). There are probably five instars present but to assign means and limits would be a doubtful procedure with the small population studied.

Direct observation revealed three facts that are not inconsistent with the assumption of five instars: 1) the measurement of the first instar is close to 17; 2) a specimen measuring 17 was observed to molt to 21.5; and 3) specimens measuring 33-35 pupated. These data correspond closely with the results of the analysis.

Pupation lasts six days at summer temperatures, and after a week or more in their galleries the adults emerge about August 1. The cycle is repeated, and those larvae which reach the proper stage of development survive the winter.

Reproduction and Environmental Resistance

To obtain some measure of the biotic potential, one-hundred brood galleries were selected at random and the egg niches counted. Variation was from 8 to 79, with an average of 44.75. In addition to the selectivity of winter, which is undoubtedly a major consideration in this latitude, at least four factors were observed to contribute to the pre-emergence mortality. A hymenopterous parasite, *Ecphylus* sp., was found occasionally in the galleries. Its frequency was far less than one percent, and it is probably of negligible value in control. Some of the larvae succumb to a fungus. Many eggs, larvae, pupae, and a few adults

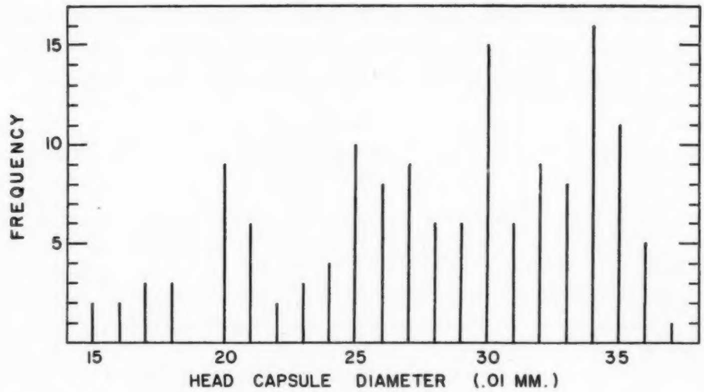

Fig. 4. Histogram of head capsule measurements.

were attacked and killed by a small, predatory mite. Cannibalism among larvae occurred in places where walls between adjacent larval galleries had broken down.

Conclusions

Pseudopityophthorus minutissimus (Zimm.) appears to have two well-marked generations in Wisconsin. Winter is spent as a nearly mature larva.

Mathematical analysis of head capsule diameters indicates that there are probably five larval instars.

Host plants recorded in Wisconsin are three species of the black oak group, and the beetle occurs throughout the state wherever the hosts occur.

Adults are capable of feeding on living tissue, and often make abortive galleries in healthy branches. The larger larvae and adults bore partially in the outer xylem.

Summary

The life history, habits, and distribution of *Pseudopityophthorus minutissimus* in Wisconsin are reviewed.

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Notes on Mites of the Genus *Typhlodromus* Scheuten, 1857 (Acarina: Laelaptidae), with Descriptions of the Males of Some Species and the Female of a New Species[1]

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From 1952 to 1955 the author has been engaged in a study of the predacious mites of importance in controlling the European red mite, *Metatetranychus ulmi* (Koch), in southern England. During this time an opportunity was afforded to become familiar with many of the species in the genus *Typhlodromus* that are thought to be of some value in this regard (Gilliatt, 1935; Nesbitt, 1951; Collyer, 1953).

Most of the species encountered were originally described by Oudemans, who frequently based his descriptions on the adult females only. It is of value in ecological investigations of mites to be familiar with both the male and the female forms of the adults. Therefore, the males of some of these species of Oudemans, collected and reared during this study, are herein described. They are of *Typhlodromus vitis* Oudemans, *T. tiliarum*, and *T. reticulatus*.

As a result of a visit to the Rijksmuseum van Natuurlijke Historie, Leiden, Holland, during which much of Oudemans' type material was examined, a discussion of *T. vitis*, *T. aberrans* Oudemans, and *Kampimodromus elongatus* (Oudemans) is included.

Also, a new species found in material sent to the author by Mr. J. H. McLeod, Officer-in-Charge of the Vancouver laboratory, is described.

Throughout the paper the nomenclature suggested by Garman (1948) for the dorsal setae of these mites is followed. Discussions of this system are given by Nesbitt (1951) and Evans (1953).

Identity of *T. vitis*, *T. aberrans*, and *K. elongatus*

Extensive collections during the study showed that the dorsal setae of the overwintering generation of females of many species of typhlodromids are much more strongly serrated than those of the summer generations. Also, the degree of sclerotization of the former is frequently considerably greater.

This is particularly the case with *T. vitis*, which was found to spend the winter under the bark of hazel, *Corylus avellana* L., in Kent. It was suspected that this dimorphism had been responsible for some confusion in the descriptions of various "new" species, and remounting and examining Oudemans' types supported the suspicion.

In most cases, the ringing material used by Oudemans for his type slides had crept under the cover glasses and completely obscured the specimens. Also, the mites were badly shrivelled and distorted. Acetone dissolved the ringing material, and when the mites were remounted temporarily in lactic acid to which had been added a small amount of lignin pink stain, they returned to their original form almost completely.

Examination of the type of *K. elongatus*, type species of the genus *Kampimodromus* Nesbitt, 1951, showed that it was merely the overwintering form of *T. vitis*. *K. elongatus* (winter form) and *T. vitis* (summer form) are compared in Fig. 1.

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A factor that contributed to this confusion was that Oudemans considered L7, a minute seta, to belong to the complex of ventral setae surrounding the ventri-anal shield (Oudemans, 1930 a). From the type, however, it can clearly be seen that this seta is truly L7, and belongs to the dorsal series.

It was further observed that the dorsal setae of the winter form are somewhat longer than those of the summer form (Fig. 1). L8 in the latter

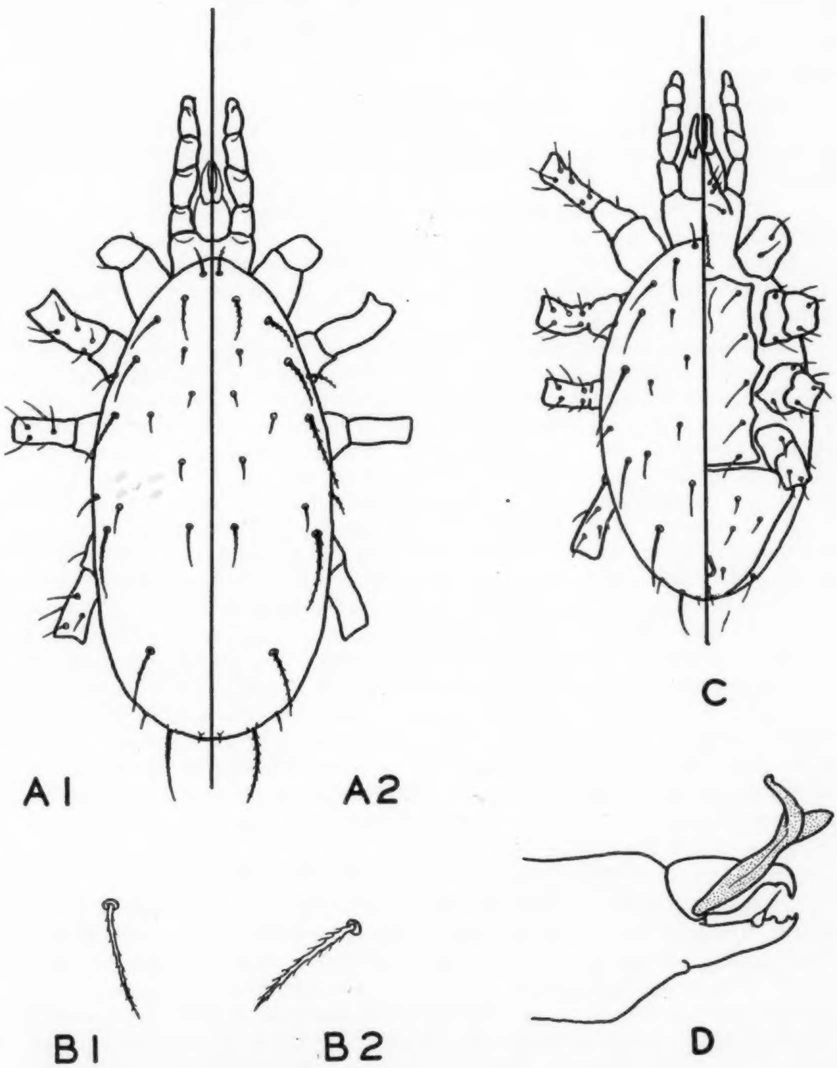

Figure 1. *Typhlodromus aberrans* (=*Kampimodromus elongatus* and *Typhlodromus vitis*). A1, summer female; A2, winter female; B1 and B2, seta L8 of the two forms; C, male, dorsal and ventral; D, male chelicera.

averages 15 μ in length, whereas in the former it averages 18 μ. L8 of the type of *K. elongatus* is also 18 μ in length.

Nesbitt (1951) suspected that *T. aberrans*, described from immature specimens only, is in reality an immature stage of *T. vitis*. Because the latter was known at that time only from its author's description and figures (the type is missing from its slide), it was impossible to settle this point. Since then, the present author has found *T. vitis* to be moderately abundant in Kent, collected specimens agreeing completely with Oudemans' figures. Many of these were reared and deutonymphs were compared with the type material of *T. aberrans*. Nesbitt's suspicion was correct, and *T. aberrans* is the immature form of *T. vitis*.

Apparently, then, three names, *T. aberrans, T. vitis,* and *T. elongatus*, exist for this species. Because the species shows the characteristics of the genus *Typhlodromus* there is no justification for its inclusion in a separate genus.

Both *T. aberrans* and *T. elongatus* were described by Oudemans in 1930 (1930 a) but *T. aberrans* has page priority. *T. vitis* was also described by Oudemans in 1930 (1930 c) but not until several months later. Therefore, *T. aberrans* is the valid name and *T. vitis* and *T. elongatus* are synonymous with it.

Typhlodromus elongatus was designated by Nesbitt as the type species of the genus *Kampimodromus*, and its synonymy with *T. aberrans* places the entire genus in synonymy with the genus *Typhlodromus*. The remaining species in the genus *Kampimodromus* (*K. heveae* (Oudemans, 1930 c), *K. hevearum* (Oudemans, 1930 c), *K. transvaalensis* Nesbitt, 1951, and *K. australicus* Womersley, 1954,) form a heterogenous group and on the evidence in hand the author considers that they should be placed within the genus *Typhlodromus* s. lat. Oudemans' type material of these species is in very poor condition and impossible to study critically. Except *K. transvaalensis,* none of the species have been recorded more than once and until more specimens are collected the true statuses of these species will remain in doubt. Because the majority were collected during the winter it is possible that their having serrated setae merely indicates they are individuals of an overwintering generation.

Despite distortion of the type specimen of *Typhlodromus hevearum* it is possible to observe that the original figure of this species (Oudemans, 1930 c) was incorrectly drawn. This species has seven lateral setae, not six as shown. The missing seta should appear somewhat medially of the margin of the dorsal shield opposite seta S2. It is doubtful whether the dorsal setae are as strongly serrated as the figure indicates.

Typhlodromus aberrans Oudemans, 1930

Male.–Chaetotactic pattern of the dorsal shield (Fig. 1,C) similar to that of the female (Fig. 1,A; Oudemans, 1930 c; Nesbitt, 1951) except that the setae-bearing portion of the interscutal membrane is fused with the dorsal shield. Thus the dorsal shield bears two setae (S1 and S2) more than that of the female, as in many if not all of the members of the genus *Typhlodromus* (Evans, 1954). Setae of lateral series faintly pectinate, those of dorsal series smooth. Relative values of the dorsal setae somewhat different from those of the females, tending to be longer in relation to the length of the shield itself. Those of the lateral series range from 20 to 31 μ in length, and those of the dorsal series from 13 to 20 μ.

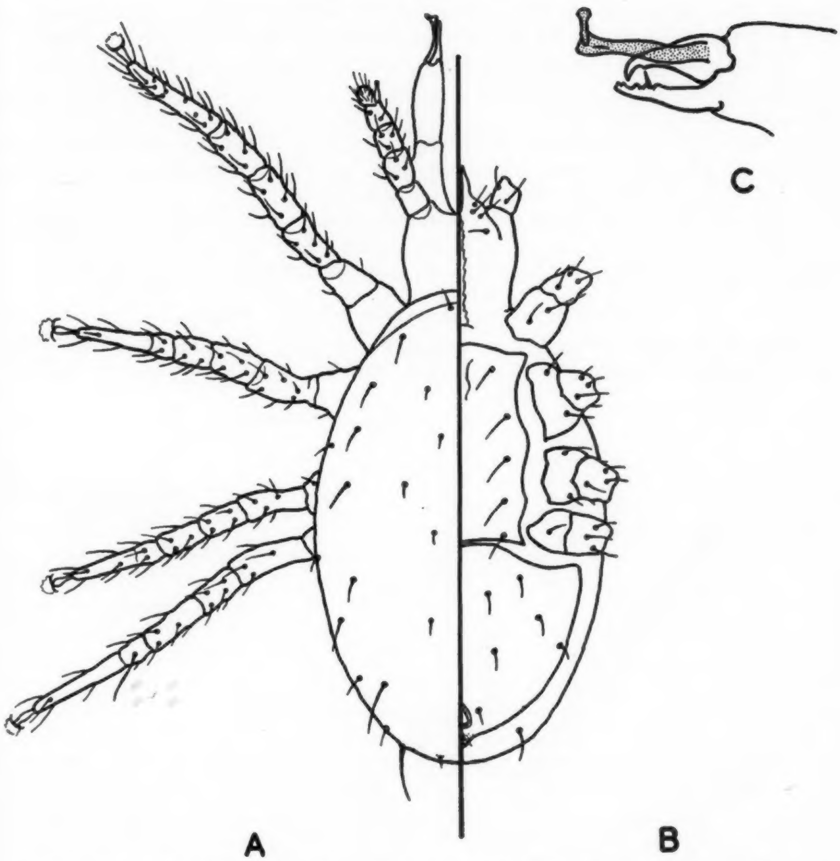

Figure 2. *Typhlodromus reticulatus*. Male. A, dorsal; B, ventral; C, chelicera.

Dorsal shield moderately reticulated and ranging (five specimens) from 227 to 235 μ in length and from 130 to 134 μ in breadth.

Ventri-anal shield 120 μ in length and 114 μ in breadth, bearing three pairs of setae in addition to para-anals and post-anal seta.

Fixed digit of the chelicerae (Fig. 1,D) 20 μ in length, bidentate, and bearing a strong pilus dentilis. Movable digit 16 μ in length, bearing one tooth together with a strong Y-shaped spermatophoral process.

The males of this species can be distinguished from those of other species having three pair of setae on the ventri-anal shield by the number and position of the lateral setae on the dorsal shield.

The specimens from which this description was made were collected during the summer of 1954 from hazel leaves near the East Malling Research Station, Kent.

Typhlodromus reticulatus Oudemans, 1930

Male.–Chaetotactic pattern of dorsal shield (Fig. 2,A) identical with that of the female (Oudemans, 1930 b: Nesbitt, 1951) excepting that S1 and S2

appear here instead of on the interscutal membranes. Dorsal shield measures (for two specimens) from 311 to 314 μ in length and from 184 to 190 μ in breadth.

Ventri-anal shield (Fig. 2,B) 160 to 165 μ in width and 130 to 137 μ in length, bearing five pairs of setae in addition to para-anals and post-anal seta. Their arrangement is unique.

Fixed digit of chelicerae (Fig. 2,C), 23 μ in length, multidentate, and bearing a weak pilus dentilis. Movable digit 16 μ in length, bearing one tooth and a hammer-shaped spermatophoral process.

Leg IV has a macroseta on basi-tarsal joint measuring 34 μ in length.

The material from which this description was made was collected in August, 1954, from broom, *Sarothamnus scoparius* (L), at Dungeness, Kent.

Typhlodromus tiliarum Oudemans, 1930

Male.—Chaetotactic pattern of dorsal shield (Fig. 3,A) identical with that of the female (Oudemans, 1930a; Nesbitt, 1951) except that S1 and S2 appear

Figure 3. *Typhlodromus tiliarum*. Male. A, dorsal; B, ventral; C, chelicera.

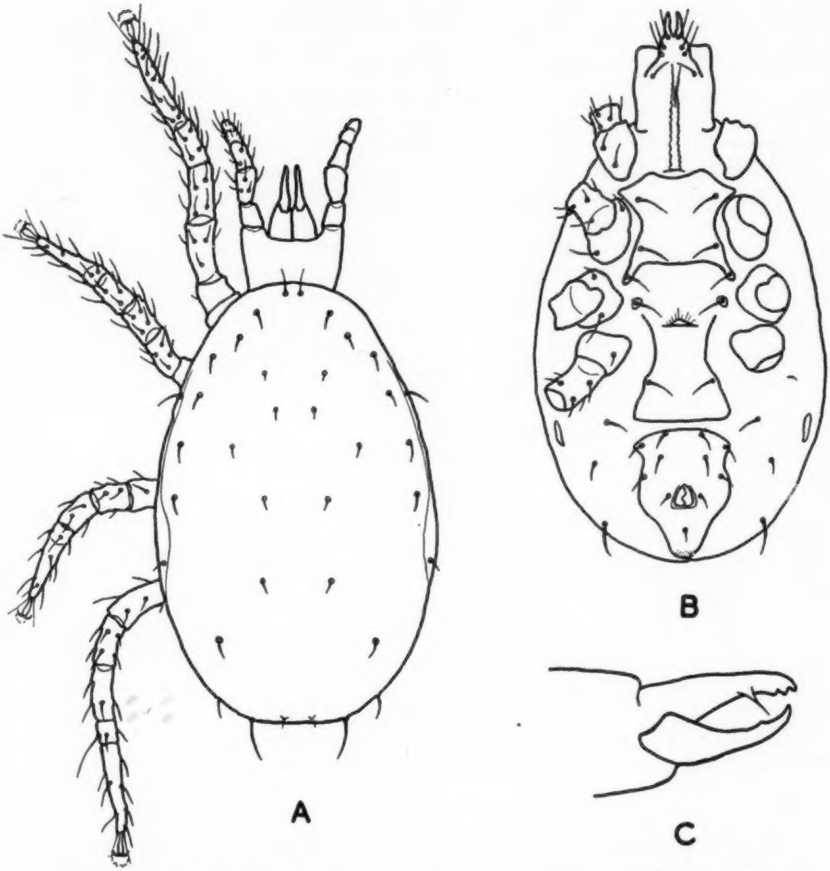

Figure 4. *Typhlodromus pini* sp. n. Female. A, dorsal; B, ventral; C, chelicera.

here instead of on the interscutal membrane. Three pairs of pores present on dorsal shield as in female. Shield (five specimens) from 257 to 261 μ in length and 127 to 147 μ in breadth.

Ventri-anal shield (Fig. 3,B) 113 to 134 μ in breadth and 87 to 127 μ in length, bearing five pairs of setae in addition to para-anals and post-anal seta, arranged in a manner similar to that of the male *T. tiliae*.

Fixed digit of the chelicerae (Fig. 3,C) 20 μ in length, bidentate, and bearing a small pilus dentilis. Movable digit 20 μ in length, bearing one tooth and a spur-shaped spermatophoral process.

The material from which this description was made was collected from unsprayed apple leaves during the summers of 1953 and 1954 from Penlan Hall, Essex, and Knole Hill, Kent.

Typhlodromus pini sp. n.

Female.–Dorsal shield (Fig. 4,A) faintly reticulate, 331 to 332 μ in length and 184 to 185 μ in breadth, bearing 16 pairs of setae, eight being along the

lateral margins (Fig. 4,A). Setae simple and, except L8, short. Lateral series, excluding L8, measuring 10 to 18 μ and dorsal series 6 to 16 μ. Seta L8 measuring 26 to 30 μ and seta M2 20 to 23 μ.

Sternal shield (Fig. 4,B) bearing three pairs of simple setae, the third pair being on strong posterolateral projections of the shield. Metapodal plates conspicuous, each bearing a simple seta. Genital shield normal, bearing a pair of simple setae on the lateral edges approximately one-third of the length anterior to the posterior margin of the shield. There is but a single parapodal plate.

Ventri-anal shield of a distinctive shape and bearing four pairs of setae in addition to para-anals and post-anal seta. It differs from that of *T. tiliae* and *T. conspicuus* by having a pronounced "waist" opposite the third pair of setae, and by the fact that the anus is far forward of the posterior edge of the shield – almost in the centre. No pores are present.

Gnathosoma and maxillary palps normal. Fixed digit of chelicerae (Fig. 4,C) 30 μ in length, bidentate, and bearing a small pilus dentilis. Movable digit 23 μ in length, bearing one tooth.

Basitarsal joint of leg IV bearing a macroseta, which averages 34 μ in length.

This species can be separated from others having only eight lateral setae by the shape of the ventri-anal shield, the position of the anus, the possession of a macroseta on leg IV, and the length of the setae on the dorsal shield. It is most similar to *T. conspicuus* (Garman).

Male.–Unknown.

Locality.–The type material (32 female specimens) was received from Mr. J. H. McLeod, Vancouver, Canada. They were collected during February, 1955, from beneath the bark of lodgepole pine, *Pinus contorta* Dougl., and white pine, *P. strobus* L., on the grounds of the University of British Columbia, Vancouver. The holotype and a paratype are in the British Museum (Natural History) and several paratypes are being deposited in the Canadian National Collection.

Summary

Kampimodromus elongatus (Oudms.) and *Typhlodromus vitis* Oudms. are synonymous with *Typhlodromus aberrans* Oudms. The previously unrecorded males of *T. aberrans* Oudms., *T. reticulatus* Oudms., and *T. tiliarum* Oudms. are described. *Typhlodromus pini* sp. n. is described.

Acknowledgments

The author is indebted to Dr. G. Owen Evans, British Museum (Natural History), London, England, for valuable assistance and advice; and to Dr. Van der Hammen, Rijksmuseum van Natuurlijke Historie, Leiden, Holland, for permission to borrow and study Oudemans' type material. This work was conducted under the direction of Dr. A. M. Massee, Head, Entomology Section, East Malling Research Station, Kent, while the author was a graduate student there. For part of the time during which the work was done the author was in receipt of a Special Scholarship for Overseas Study from the National Research Council of Canada, and this is gratefully acknowledged.

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A Fungous Enemy of the Pea Aphid, *Macrosiphum pisi* (Kaltenbach)[1]

By D. M. MacLeod[2]

Introduction

During an investigation into the importance of fungal disease as a factor in the control of orchard pests throughout the Annapolis Valley,[3] Nova Scotia, the haemocoele of large numbers of *Macrosiphum pisi* (Kaltenbach) was found to be infected with a fungal growth that resulted in death. This fungus was identified from mounted specimens as *Empusa* (= *Entomophthora*) *aphidis* Hoffman.

Field Observations

Although no exact tests were made, it was apparent that infection by the fungus was very high among the insects in the infected areas. A field collection of 3,822 aphids showed 41.4% mortality, another 34.7% were infected, whereas the remaining 23.9% appeared normal.

The aphids seem to be susceptible to this disease in all stages of development; even the very young nymphs were frequently found to contain hyphal bodies. Invariably the colour of live infected nymphs gradually changes from dark green to a characteristic yellowish-green. This abnormal coloration was the only constant or well-marked characteristic indicative of the presence of the disease in the bodies of living aphids. There is no apparent change in size or shape, although after death the insects may become shrunken. As the

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Figure 1. Three dead and one normal potato aphid (lower right) on under surface of lupine leaf. The infected aphids eventually shrivel up, become firm and brittle. Note that the legs and antennae of diseased aphids are covered with conidiophores and conidia (whitish in colour). 10x.

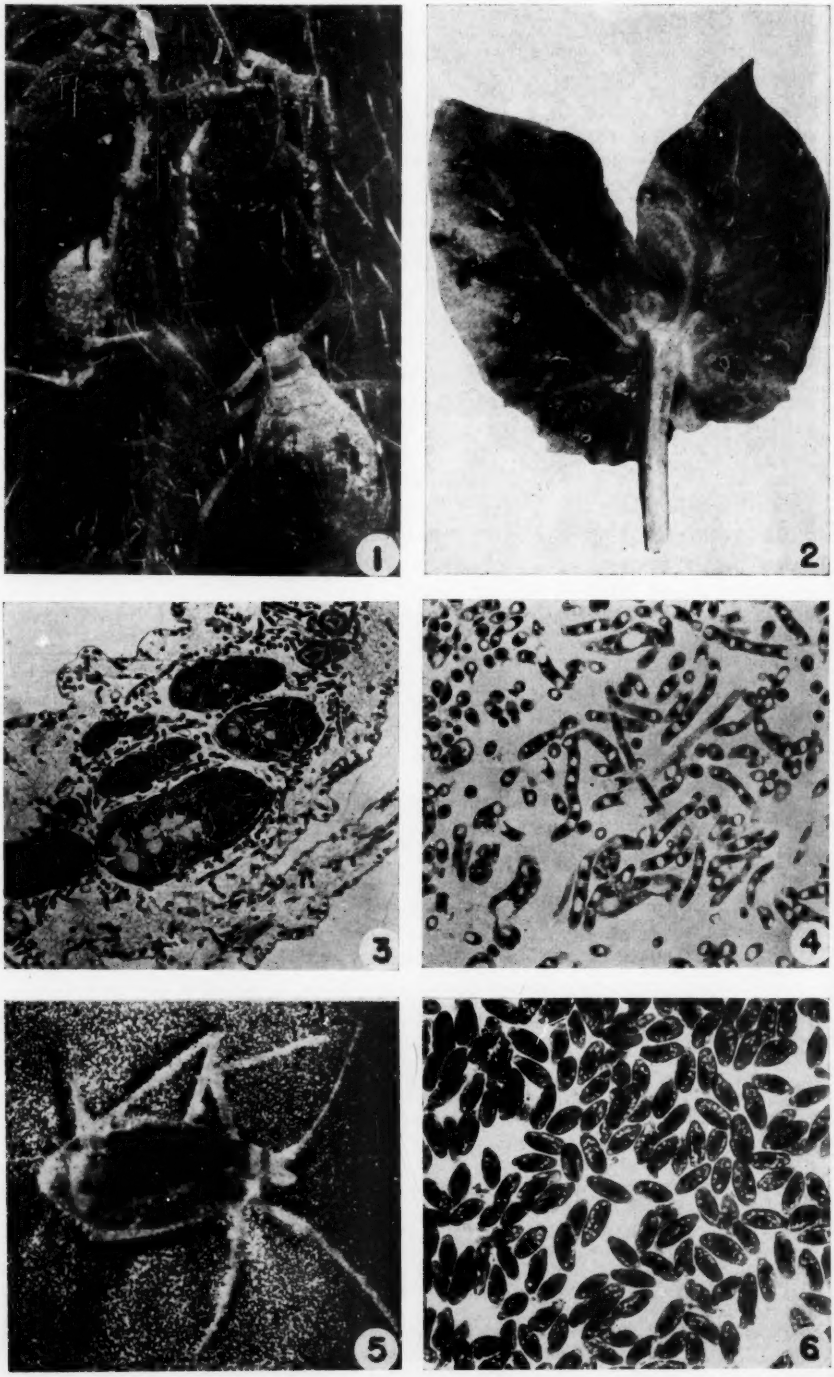
Figure 2. Dead pea aphids on the under surface of leaf-like stipules from a pea plant. Note that in a few cases the protruding conidiophores and conidia form a whitish margin around the outer edge of the insect. 1.7x.

Figure 3. Prepared section from a living infected aphid. While the fungus is present in the body cavity, there is no evidence of it having penetrated the internal organs at this stage. 100x

Figure 4. Prepared section from an infected aphid showing the hyphal bodies characteristic of *E. aphidis*. 240x.

Figure 5. The cast off conidia forming an aureole around a dead aphid. 10x.

Figure 6. Conidia of *Empusa aphidis*. 405x.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fungus appears on the surface, the aphids turn pale cream to reddish-brown. The first filament to protrude develops through the ventral surface just before or immediately following the death of the insect. This structure, called a "hold-fast" or rhizoid fastens the insect body to the surface of the leaf.

During the period (July 14-26, 1947) over which the fungus reached epidemic proportions, the daily rainfall averaged 0.44 inches with a mean relative humidity of 81.2%. The average maximum and minimum temperatures were 85.5°F. and 64.2°F. respectively. During this period a rich succulent growth heavily infested with aphids developed throughout the peafields. It would thus seem that the same environmental conditions favour the rapid development of plant growth, the rapid build up of a heavy aphid population, and the efficient spread of the fungus.

Various aphids occurring in the Annapolis Valley were checked for susceptibility to the fungus. The potato aphid, *Macrosiphum solanifolii* Ashmead, on *Lupinus* species and the pea aphid (Figs. 1 and 2) alone showed infection. According to Charles (1), however, the green apple aphids, *Aphis pomi* De Geer, is also attacked by this fungus.

Notes on the Morphology of the Fungus

The conidia are ovoid to elliptical or subfusiform, commonly asymmetrical, and very variable, with a papillate base. They contain numerous oil globules and range in size from 13.0 to 24.0 μ by 7.5 to 13.0 μ, averaging 18.5 by 9.0 μ (Fig. 6). The conidiophores are simple and occasionally digitate. Resting spores were reported in the earlier descriptions of this species and also by Petch (2) in 1939. They were not found in any of the specimens examined in this instance, however, nor were they observed by Thaxter (3), despite the fact that this fungus is common in the United States.

Sections prepared from living insects in various stages of infection revealed that the fungus does not produce a bunched mycelium internally, but multiplies by the formation of hyphal bodies (Figs. 3 and 4). These consist of short, thick fragments of various sizes and shapes that are continually produced by fission and budding until the insect is more or less filled with them. Shortly after the death of the insect, tubular outgrowths, the conidiophores, emerge. These processes extend from the hyphal bodies. Finally, conidia are abjointed at the tips of the conidiophores and forcibly discharged at maturity, forming an aureole about the dead insect (Fig. 5).

Dissemination

The primary spores, as they are violently discharged, may be carried some distance by air currents. Rain may also aid in the spread of this organism. It is probable, however, that migration of infected nymphs and winged adults, with subsequent spore discharge among healthy aphid colonies, is the most effective means of dissemination.

Acknowledgments

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The Immature Stages of *Stethorus punctillum* Weise (Coleoptera: Coccinellidae)[1]

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Various authors have given general descriptions of the immature stages of various species of *Stethorus*, and Böving (1917) described certain morphological features of the larvae of *S. punctum* (Leconte) and *S. utilis* (Horn), but no complete account of the morphology of these stages in any species of the genus has apparently been published. Clement (1880) gave the most thorough of the earlier descriptions of the immature stages of *S. punctillum* Weise.

The following descriptions are based on material reared from adults captured at Vineland Station, Ontario, where the occurrence of *S. punctillum* was recently recorded by the author (Putman, 1955). Approximately 25 individuals of each stage were examined.

Egg.—Figured by Collyer (1953). Attached to the substratum longitudinally, elongate with bluntly rounded ends, 0.22 to 0.23 by 0.34 to 0.39 mm. Chorion very finely reticulate; white to pale yellow when fresh, becoming dusky as the embryo develops.

Fourth (*last*)- *instar Larva*.—Dark greyish to reddish-brown with darker tubercles and sclerites. Fusiform, widest on metathorax and first abdominal segment. Head (Fig. 1) prognathous, slightly deflexed. Cranium in dorsal aspect more or less rectangular, slightly wider than long, widest near middle; sides gently curved, occipital margin nearly straight. Antero-lateral margins of cranium obliquely truncate behind to the ends of the clypeolabral suture, which is slightly convex and about two-fifths as wide as the greatest width of the cranium. Dorsum of head without distinct sutures. The membranous gular region extending nearly across the posterior width of the cranium, narrowing anteriorly to the bases of the maxillae. Head with many long, finely pectinate setae, the longest about half as long as the width of the cranium. Labrum deflexed, broadly curved distally, more strongly rounded at sides. Two very large

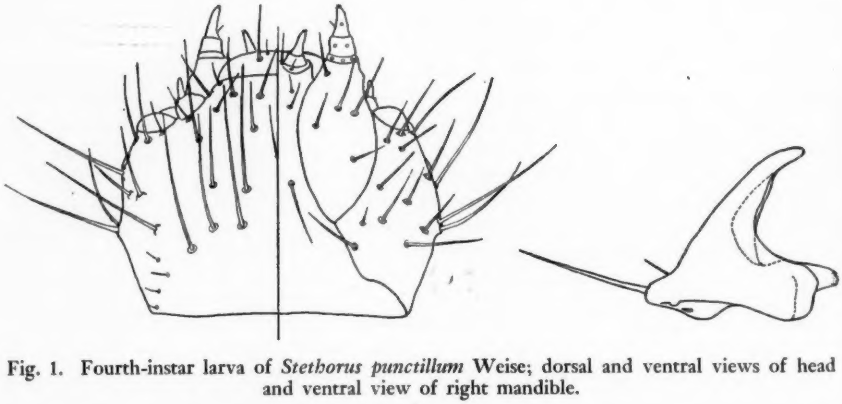

Fig. 1. Fourth-instar larva of *Stethorus punctillum* Weise; dorsal and ventral views of head and ventral view of right mandible.

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ocelli, one dorsal and one ventral, directed forward at each anterolateral angle of head; a third ocellus much smaller, possibly functionless, on each side of the cranium behind the large ocelli.

Antenna greatly reduced, moundlike, wider than long, without distinct segmentation; terminated by a stout spikelike sensillum about 1.5 times as long as the rest of the antenna, probably homologous with a similar but relatively smaller structure on the second segment of other species illustrated by Gage (1920); beside it a group of minute sensilla presumably arising from the remnant of the third segment. Mandible falcate, deeply grooved internally, apex acute and entire; a prominent blunt mola with two longitudinal ridges; a membranous prostheca, very finely setose apically, above and distad of the mola and projecting beyond it. The molae of the opposing mandibles do not meet but work against the hypopharyngeal bridge as described by Böving (1917) in *Hyperaspis*.

Cardo and stipes of maxilla united, longitudinally ovate, pointed basally; palpifer large, length and width nearly equal, segmentlike but without evident division from cardo-stipes. Maxillary palpi large, three-segmented, each arising from a narrow articular ring; first segment much wider than long; second about the same length but thinner; third thinner than second, longer than first and second together, tapering slightly to a rounded tip bearing about 10 very small peglike sensilla. The distal part of the maxilla, or mala, a soft, membranous, undivided lobe, largely concealed ventrally by the palpus.

Labium soft and membranous, undivided, without evident division from the gula. Labial palpus well developed, two-segmented, arising from a narrow articular half-ring; first segment wider than long; second narrow, slightly tapering, length about four times the greatest width; tip blunt with one larger and several smaller peglike sensilla.

Pronotum transversely elliptical, about 1.4 times as wide as long, widest slightly behind the middle, closely set with minute rigid spicules and with many long, finely pectinate setae.

Meso- and meta-terga each more than twice as wide as long, indistinctly divided longitudinally into two heavily sclerotized regions bearing setae and spicules like those on the pronotum. The conspicuous mesothoracic spiracle and the rudimentary metathoracic one situated below the cephalolateral angle of the tergum; no tubercles or spines in the spiracular region. According to Böving (1917), in the tribe Scymnini (including *Stethorus*) this region is united with the tergum. In *S. punctillum* the spiracular region is membranous and distinct from the lightly sclerotized tergum although they are not separated by a suture. On each thoracic pleurum below the caudolateral angle of the tergum, a tubercle bearing three setae. Meso- and meta-thoracic pleura each with a narrow, oblique sclerite; rest of pleura and sterna membranous without distinct divisions. Legs stout; femora and tibiae subequal in length, coxae slightly longer; tips of tibiae each with about 18 long tenent hairs; tarsunguli deeply toothed at bases.

Abdominal segments 1 to 8 with low, lightly sclerotized tubercles (*verrucae* of Gage, 1920) bearing pectinate setae of greatly varying length and many minute spicules; four tubercles arranged transversely on each tergum, one on each pleurum, and four reduced ones on each sternum; inner tergal tubercles with eight or nine setae up to 0.5 mm. long; outer tergal, five or six up to 0.5 mm.; pleural, five to eight up to 0.92 mm. Sternal tubercles small, not sclerotized, each with four to six short setae. Spiracles on terga near cephalolateral angles. Ninth segment with tubercles coalesced, without spiracles; tenth segment normally invaginated but eversible as an anal sucker.

The membranous parts of the integument of the thorax and abdomen are finely roughened with closely set points, most evident on the dorsum.

In the intersegmental membrane between the first and second abdominal terga are a pair of longitudinal invaginations, probably the openings of repugnatorial glands.

Earlier Instars.—The earlier instars are similar to the fourth, the most obvious difference being fewer setae on the tubercles. Length of first-instar larva, 0.58 to 1.04 mm.; second, 0.90 to 1.46; third, 1.39 to 1.87; fourth, 2.01 to 2.88. Average width of head capsule of eight larvae: first instar, 0.143 mm.; second, 0.198; third, 0.242; fourth, 0.302.

Pupa.—Similar to that of *S. punctum* as figured by Weldon (1909); free of the larval exuviae, which are pushed down about the anal attachment. Dorsum piceous-black, variably lighter on mesonotum and laterally on abdominal tergites, pale ventrally; covered, except ventrally, with pale yellowish-brown pubescence composed of longer, tapering setae mixed with shorter, clavate ones. Ovate, widest at first abdominal segment, depressed and closely appressed to the substratum, to which it is attached by the anal end and by a soft process from the frontal region of the head. If the frontal process is forcibly detached from the substraum it shrivels into a rough scar. Such pupae produce normal adults. Pronotum large, deflexed at right angles to the rest of the thorax. Head directed caudad. Elytra extending to the third abdominal segment laterally and to the caudal edge of the fourth ventrally; hind wings extending to the fifth.

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